

Finding the appropriate rules for image analysis with the DialInspect family of particle analyzers

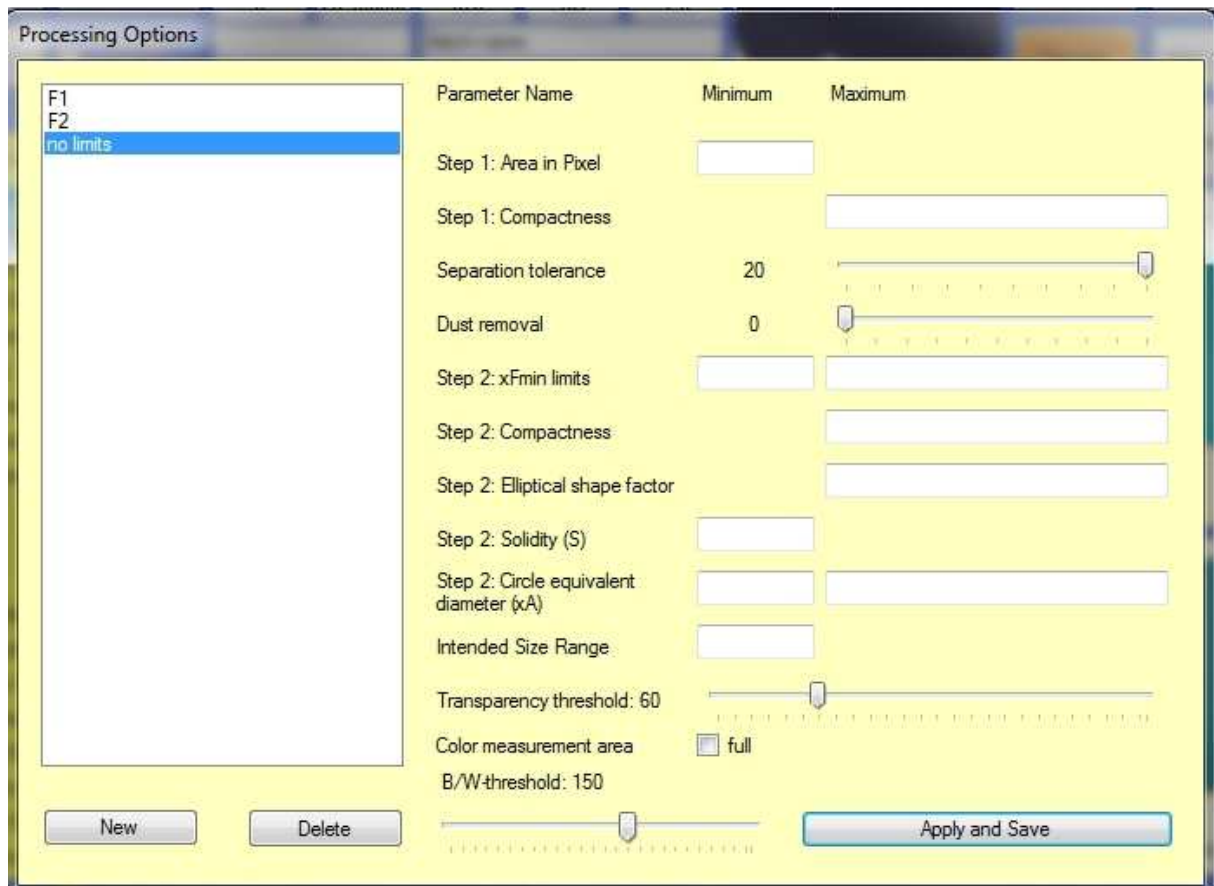
This guideline applies to the following products

DialInspect-S, the stand-alone particle analysis software

DialInspect.OSM, the computer controlled optical scanning microscope

DialInspect-P, the fast production scale particles analyzer

The goal of the document is to help and remind the user of the particle analysis software how to use the rules and restrictions for digital image analysis in order to get persistent and expressive results.



The image analysis in DialInspect is carried out in a series of processing steps. We will have a look at every step and the tools for influencing the performance and results of the step.

A) conversion from color to greyscale and from greyscale to binary image

The default type of lighting in the DialInspect system is transmissive lighting, the particles are located between light source and camera lens. The background of the image always appears brighter than the particles. The software separates all parts of image from the background, which appear darker than a certain value (i.e. the "**B/W THRESHOLD**"). The proper setting of the threshold is crucial for precise size measurements. A value of -1 lets the program find a threshold value automatically based on the histogram of the image pixel values. This is recommended if you have image files from other sources, where the background brightness differs from the normal values.

NOTE: all image areas, which are connected to the image borders after binarisation, will be omitted in the following analysis steps.

DEVICE SPECIFIC: As DialInspect-P controls camera settings and lighting automatically please keep the B/W threshold = 150.

B) Step1: particle analysis

The binary image from A) is being searched for all objects which don't touch the borders of the image. A first restriction can be used in order to exclude dust particles from further calculations by setting a minimum particle area ("**AREA IN PIXEL**"). All particles occupying fewer pixels than the limit will be omitted. This will speed up the following analysis steps significantly and is highly recommended. A second restriction is the maximum compactness value ("**COMPACTNESS**"), which may exclude groups of particles from further processing.

NOTE: if the minimum area is accidentally set too high then small particles will not appear in your results!

C) Separation tool

The resulting collection of particle from C) may consist of single particles as well as of groups of particles, where single particles are touching each other. DialInspect provides an automatic separation tool, which can cut touching particles into separate particles. The tolerance level of the tool can be adjusted by the slider "**SEPARATION TOLERANCE**" from 2 to 20. The minimum tolerance of 2 lets the tool cut quite aggressively, the maximum value of 20 switches the cutting algorithm completely off.

DEVICE SPECIFIC: On DialInspect-P it will be a good idea to reduce the feeding rate of the vibration feeder, if there are too many touching particles in the image. A lower feeding rate results in a lower

number of particles in the image and consequently lesser chances that particles stick together occasionally.

D) Dust removal tool

The dust removal routine can reduce or completely remove small attachments like hairs or debris from the particles which are the result of C). The routine at first removes n layers of pixels from the objects and then puts the same number n of layers back onto the remaining objects. Small objects with a dimension less than the number of the removed pixel layers will completely disappear. The number n can be adjusted with the slider "**DUST REMOVAL**". A value of 0 switches the routine off.

NOTE: The shape of the objects will be changed depending on the ratio between object size in pixels and the number of removal cycles n . Compare only results which were calculated at the identical settings of the processing options.

E) Step 2: Particle analysis

The resulting objects from D) are fed again into a complete series of size and shape analysis. A set of restrictions is available which can be used to specify which kind objects truly represents the batch of particles and which objects must be rejected. There are size based parameters with entries for minimum and maximum values and shape based (size independent) parameters where only one limit may be set.

The size based parameters are "**xFMIN**" (minimum Feret diameter) and "**xA**" (circle equivalent diameter), both in millimeters. The size range should not be too narrow, as larger or smaller particles may be part of the batch unexpectedly. If the restrictions are too tight you will not be aware of over- or undersized particles. For the analysis of irregular shaped particles it is very easy to use an upper limit for x_A in order to exclude doubles and bigger groups. But you should try a better physical particle separation first.

Shape based parameters are "**COMPACTNESS**", "**ELLIPTICAL SHAPE FACTOR**" and "**SOLIDITY**". They are size independent, however there is an influence of the image resolution (the pixel size) on the results. From the parameter definition table you know that Compactness and Elliptical shape factor have a value range from 1 to infinity, so only a maximum can be specified. Solidity is an ISO compatible parameter, its values range from 0 to 1. A minimum value can be specified. Groups of particles usually exhibit higher values in compactness and elliptical shape factor, and lower values in solidity. Please use the interactive tools in order to adjust the restrictions for your product.

F) Color and transparency analysis

The color and greyscale analysis will be done automatically on the objects which have passed the restrictions in E). The slider “**TRANSPARENCY THRESHOLD**” defines which part of the object is considered as transparent. Object parts darker as the slider value are not considered as transparent.

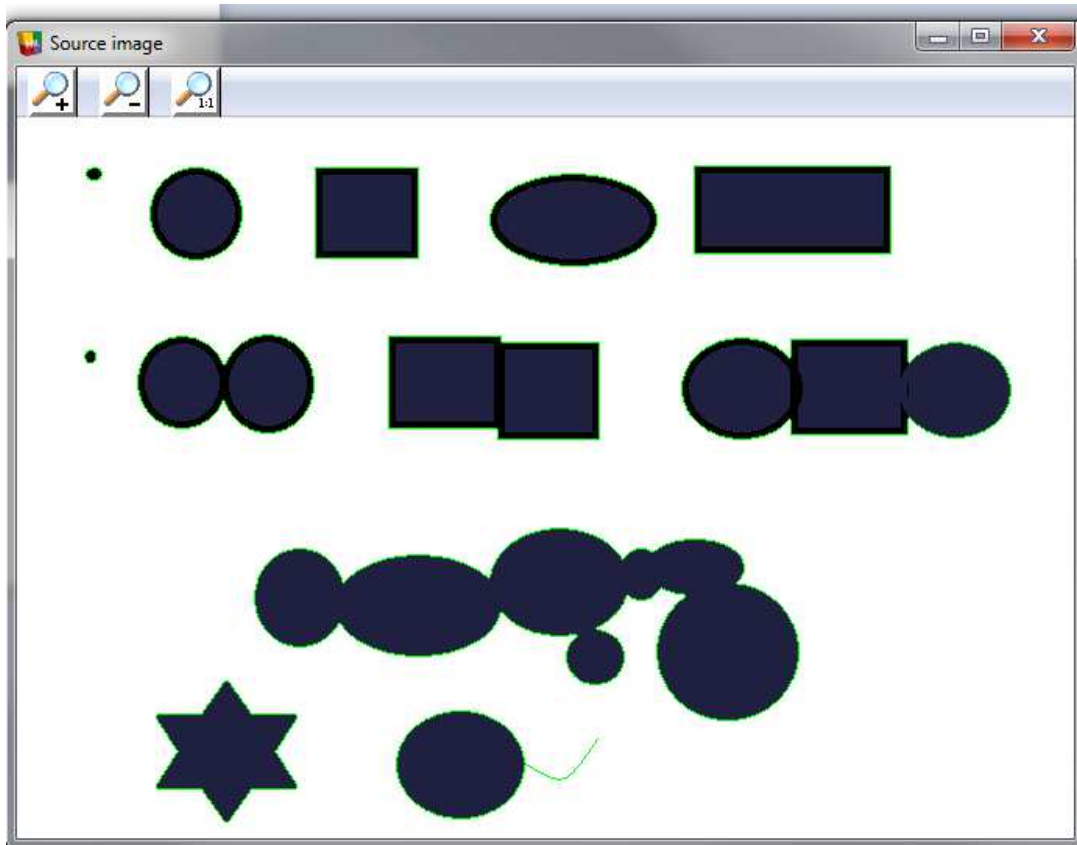
The checkbox “Color measurement area” defines, if the average color of the whole object area should be calculated or just the color of the transparent part of the object.

NOTE: Only results from identical settings can be compared.

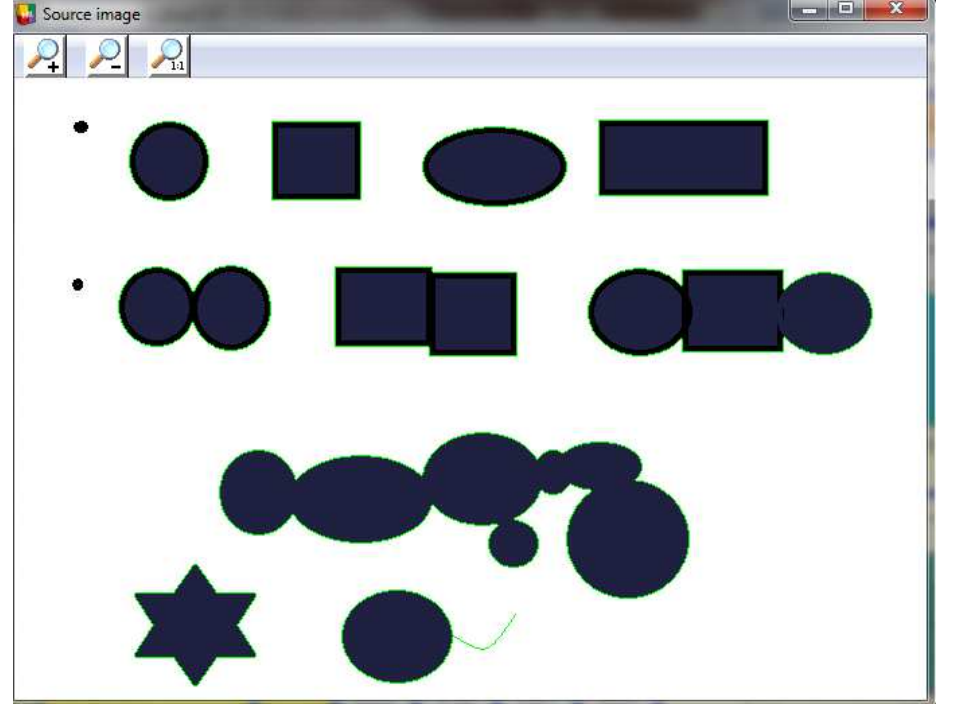
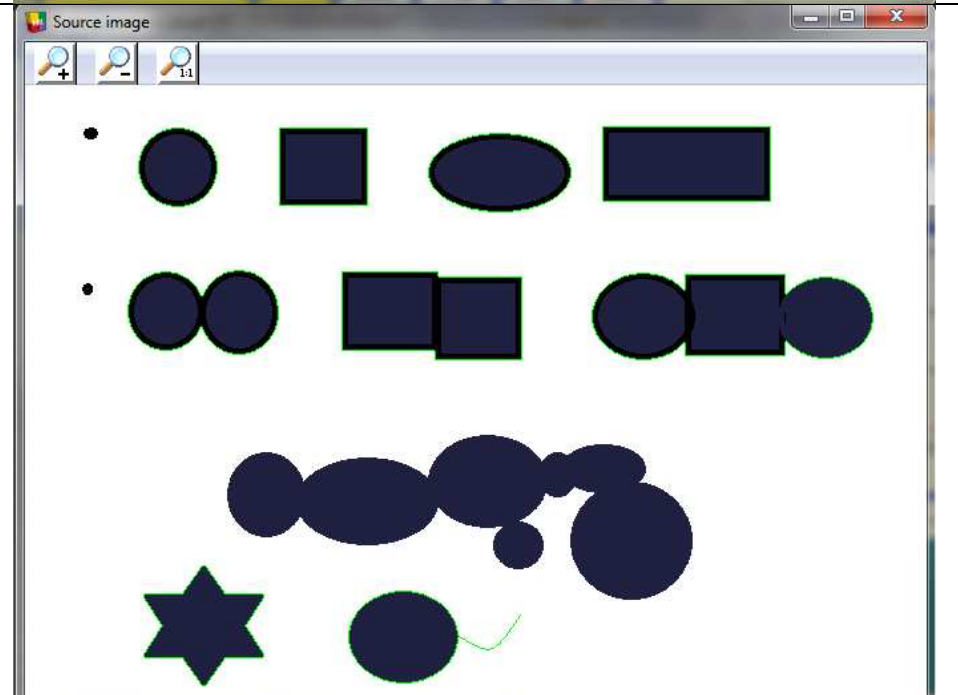
NOTE: The entry field “**INTENDED SIZE RANGE**” has no influence on the calculation results. It is just a reminder for the purpose of the filter.

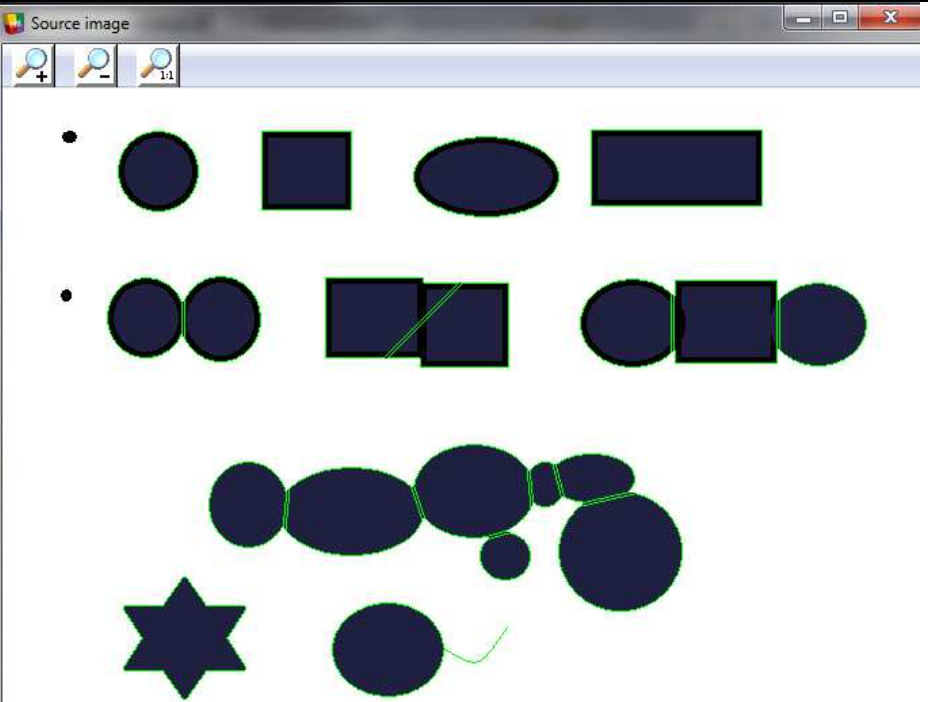
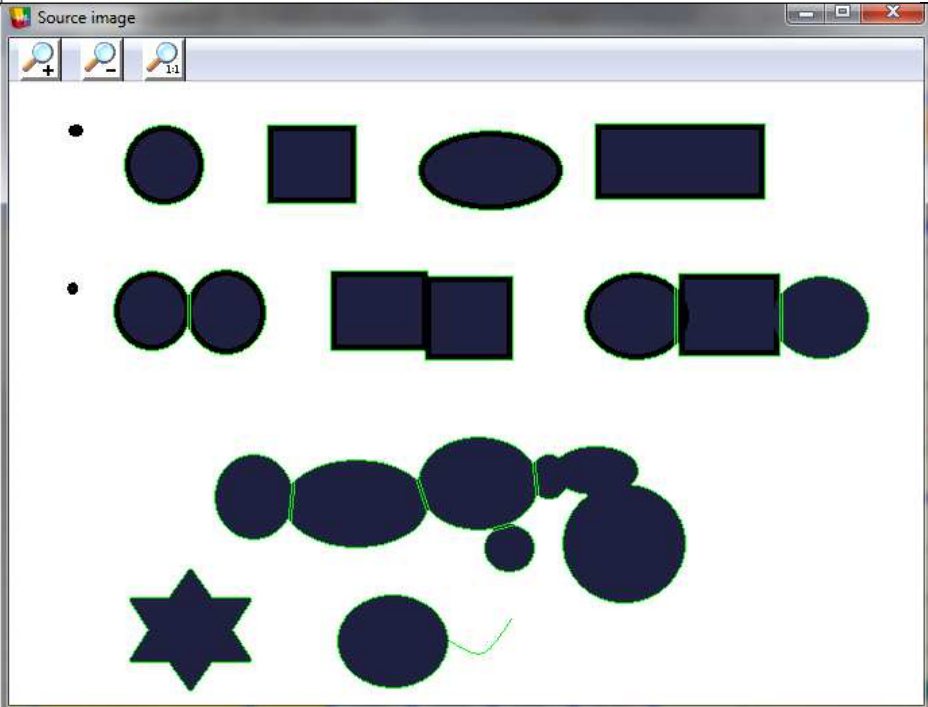
Examples for the processing options

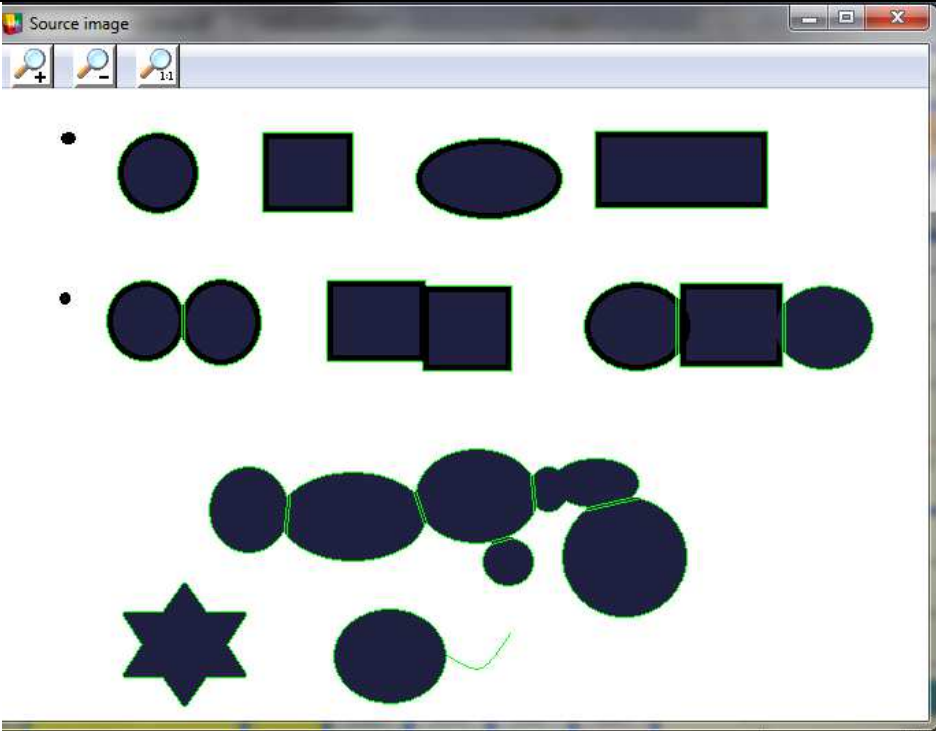
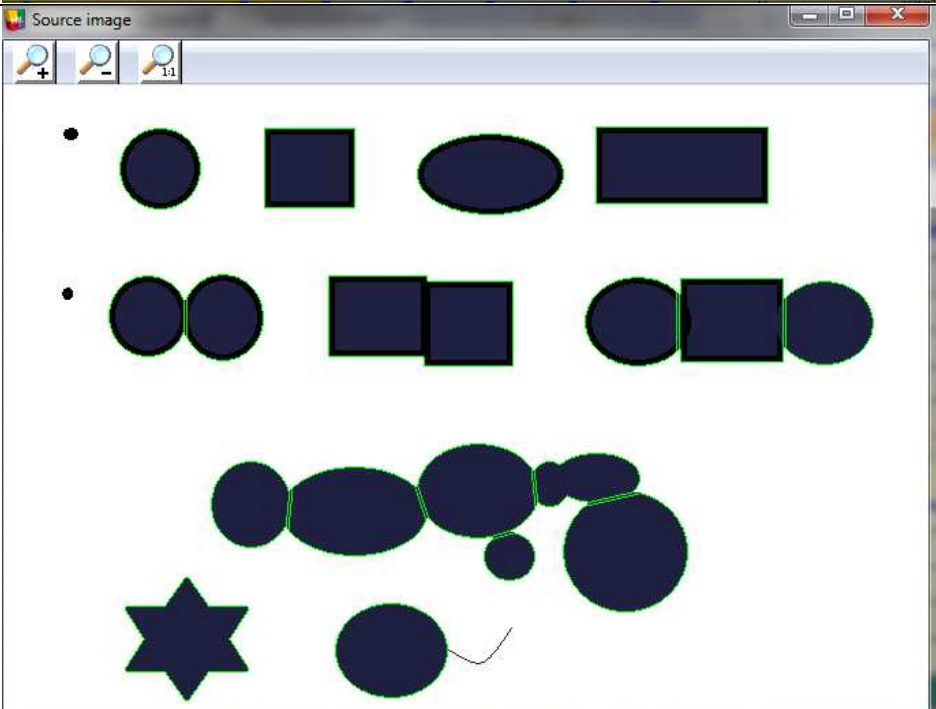
The following examples will use the same source image, which contains typical objects as we find them in the images from the microscope, a scanner or from the camera system on DialInspect-P.

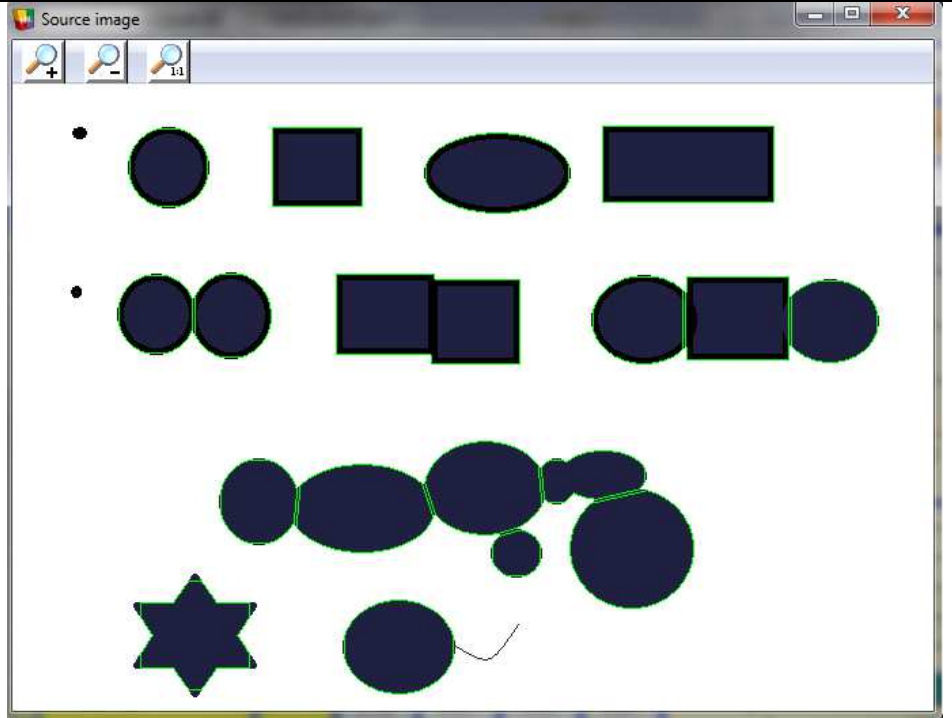
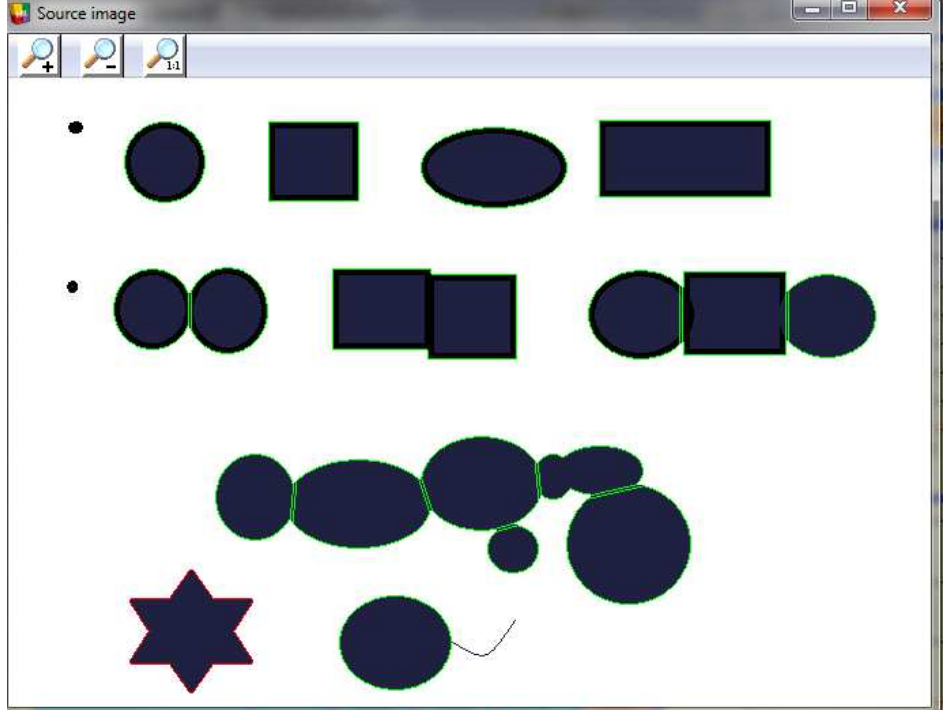


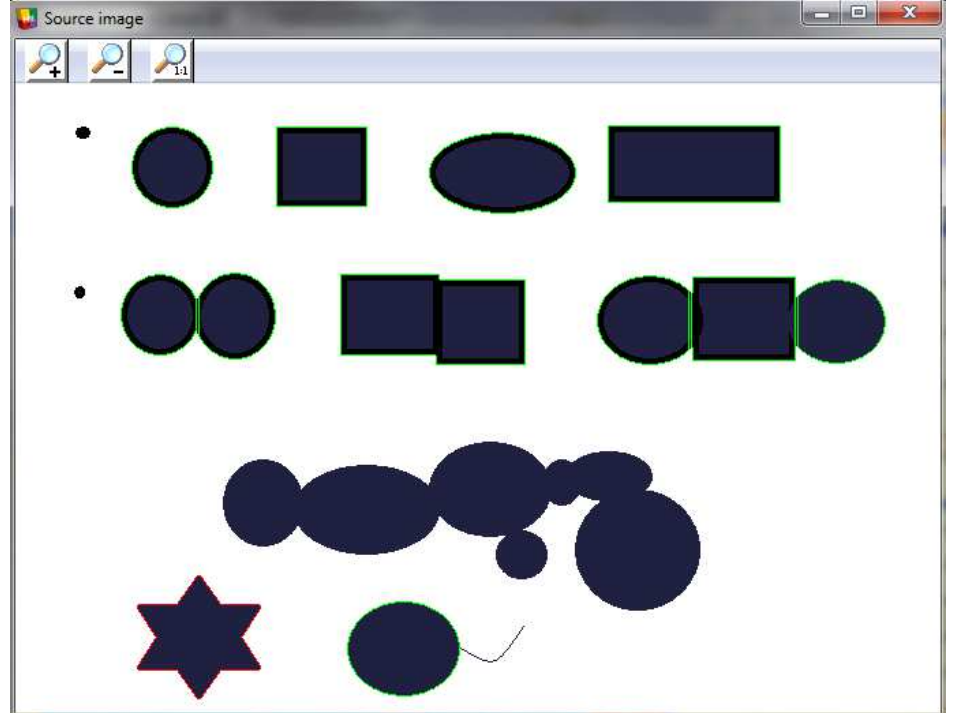
The image contains small spots (usually dust or debris), single objects like circle, ellipse, square, rectangle and star. Groups of the single objects are presented as well. A circle with an attached hair represents typical problem when measuring real powders.

<p>Dust removal</p> <p>Min.Area = 500</p>	
<p>Dust removal + removal of the group of 7 circles and ellipses</p> <p>Min. Area= 500 max. Compactness= 3</p>	

<p>Min. Area= 500</p> <p>Separation tolerance = 2</p> <p>(the touching squares are aggressively separated)</p>	
<p>Min. Area= 500</p> <p>Separation tolerance = 10</p> <p>(the touching squares are not separated, the group of ellipses is separated into 4 ellipses and one group of 3 ellipses)</p>	

<p>Min. Area= 500</p> <p>Separation tolerance = 3</p> <p>(the touching squares are not separated, the group of ellipses is separated into 5 ellipses and one group of 2 ellipses)</p>	
<p>Min. Area= 500</p> <p>Separation tolerance = 3</p> <p>Dust removal = 1</p> <p>(the touching squares are not separated, the group of ellipses is separated into 5 ellipses and one group of 2 ellipses, the hair was removed from the last circle)</p>	

<p>Min. Area= 500</p> <p>Separation tolerance = 3</p> <p>Dust removal = 5</p> <p>(the touching squares are not separated, the group of ellipses is separated into 5 ellipses and one group of 2 ellipses, the hair was removed from the last circle, the dust remover has changed some shapes)</p>	
<p>Min. Area= 500</p> <p>Separation tolerance = 3</p> <p>Dust removal = 1</p> <p>Min. solidity = 0.85</p> <p>(the touching squares are not separated, the group of ellipses is separated into 5 ellipses and one group of 2 ellipses, the hair was removed from the last circle, the star shaped object is rejected by the solidity filter)</p>	

<p> Min. Area= 500 Max. Compactness=3 Separation tolerance = 3 Dust removal = 1 Min. solidity = 0.85 </p> <p> (the touching squares are not separated, the group of ellipses was rejected in step 1 by the max. compactness filter, the hair was removed from the last circle, the star shaped object is rejected by the solidity filter) </p>	
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Depending on the particle shapes of your actual powder you may need to weaken the shape restrictions and introduce some size restrictions based on xA.

NOTE: Analysis quality must be the primary goal. Images or samples with poorly separated particles require a sophisticated set of restrictions in order to analyze single particles only.