

# dotCubeHelp

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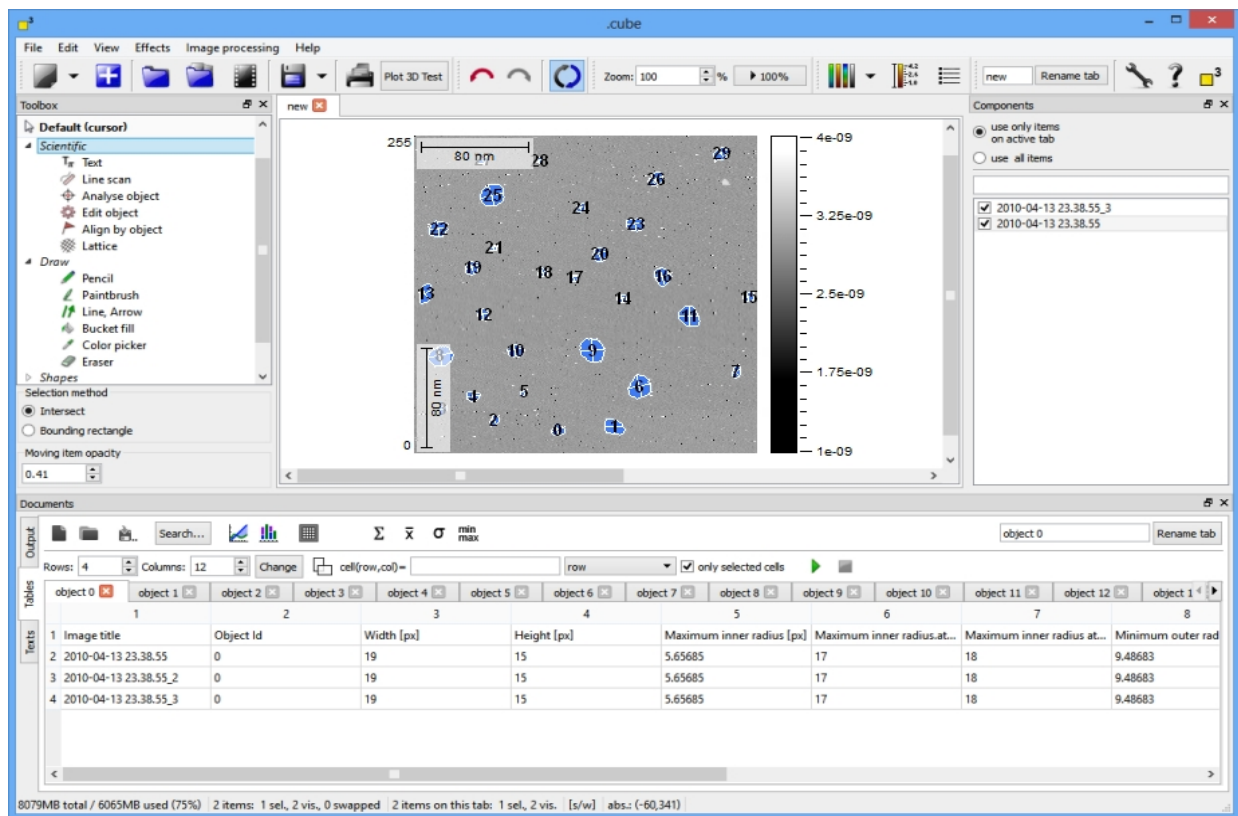
## Introduction

Welcome to a new way of analyzing topographic data. On the following pages we will introduce you to our concept of analyzing data on the fast-track, getting accurate results and managing easily large data bundles. The documentation will explain every function in detail and will help you getting started.

**3** contains six major elements:

- The [image processing](#) function group in the task bar containing advanced scientific functions
- Advanced [scientific effects](#) to work on image data placed in the task bar
- The [icon bar](#) is located thereunder with shortcuts of major control elements
- The [analyzing playground](#) in the screen center is called "[collection](#)": where you look through your data, play with effects, prepare presentations,... - basically your workbench
- The [scientific tool bar](#) is located on the left with lots of fabulous and handy instruments
- The [spread sheet section](#) at the bottom with extensive calculation and [plotting](#) options

Working with dotCube follows **one basic rule: Every effect or function will be applied to any selected item**. This basic concept simplifies incredibly the handling of large data bundles. For instance if you mark a search area in one image for analyzing an object, this very object will be tracked in every other selected image and its properties will be presented in a well-ordered table structure ready for further analysis.



## System requirements

During the creation process of dotCube, we focused on fast although greatly efficient algorithms. Therefore, dotCube runs fluent and sufficient even on simpler systems.

The minimum requirements are

Property	minimum requirement
Screen resolution	1280pixels x 720 pixels



<i>Processing unit</i>	<i>1GHz x86 or similar</i>
<i>RAM</i>	<i>512MB</i>
<i>Operating system</i>	<i>Windows XP or higher, Linux or Mac OS</i>

For smooth and joyful operation we suggest

<b>Property</b>	<b>recommended requirement</b>
<i>Screen resolution</i>	<i>1600pixels x 1200 pixels</i>
<i>Processing unit</i>	<i>1.7GHz x86 or similar</i>
<i>RAM</i>	<i>2GB</i>
<i>Operating system</i>	<i>Windows XP or higher, Linux or Mac OS</i>

## Global shortcut keys

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The following global shortcuts provide an easier and faster handling of many functions in dotCube:

### Selection

<b>Key</b>	<b>Function</b>
Third mouse button	Click with the 3rd mouse button to select images regardless which scientific tool is activated.

## File formats

---

The dotCube software is working at its best with native microscopy image files. These native file formats contain usually meta data which define the auxiliary conditions of each measurement project. Furthermore the resolution of each data point is optimized for your very special measurement system. Both features help you on the one hand to organize your measurement data in an efficient way and on the other hand ensures the most precise results during data evaluation especially with dotCube. Our developers team is working on integrating new native microscopy file formats. See the list below of already [integrated native formats](#). Additional, you might use the option to import text based files as well as typical image files.

Read on for further explanation:

- [Supported native microscopy file formats](#)
- [Importing CSV-, ASCII- or similar structured TEXT-files](#)
- [Load typical image files](#)

### Supported native microscopy file formats

Until now, dotCube is able to read the native file formats from the following microscopy companies:

- Createc (\*.dat)
- Omicron (\*.flat)
- RHK (\*.sm4)
- Specs (\*.mul; \*.flm)

If dotCube currently does not support your file format, we offer two solutions:

- You might choose to convert your data in ascii-, csv-, or text-files or use typical image file formats like \*.bmp, \*.jpg etc.

- You could send us a file format description along with some test data and we will work on supporting your very special native file format.

## Importing CSV-, ASCII- or similar structured TEXT-files

The open dialog of dotCube supports two kinds of text file formats:

- Line-by-line z values, i.e. every number is interpreted as z value
- Coordinates in the format: x, y, z

The first case describes the default setting of the import algorithm. If nowhere in the file header stated contrarily, the text data will be interpreted as line-by-line z-only values. Hence, an image with the dimensions of 3x3 pixels will be created. The first numerical line is interpreted as  $(x=1, y=1, z=3)$ ,  $(x=2, y=1, z=4)$  and  $(x=3, y=1, z=5)$ , followed by the next line with the coordinates  $(x=1, y=2, z=4)$ ,  $(x=2, y=2, z=5)$  and  $(x=3, y=2, z=3)$ .

```
Optional header: line-by-line z values
3, 4, 5
4, 5, 3
1, 5, 0
```

The latter case will be applied, if the header states somewhere "x y z" separated by the same separator used between the numerical values. Here, an image with the dimensions of 4 (defined by a maximum x value of  $x=4$ ) as image width and 5 as image height (defined by a maximum y value of  $y=5$ ) will be created. The first coordinate is interpreted as  $x=3, y=4, z=5$ , followed by the next one interpreted as  $x=4, y=5, z=3$ .

```
Mandatory header: x, y, z
3, 4, 5
4, 5, 3
1, 5, 0
```

## Load typical image files

dotCube is able to read a large number of typical image files. Keep in mind that the z resolution of image files often amounts to 8 bits. This means that you will get only  $2^8=256$  different height levels in z between the lowest and the highest region within the image. In contrast, some native microscopy file formats support a 32 bit resolution of z values, leading to  $2^{32}=4294967296$  different height levels and offering much more detail.

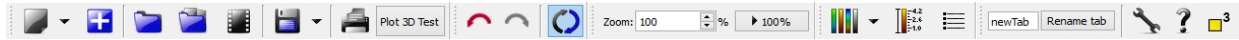
Here, you find a list with supported image file formats:

- bmp
- gif
- jpeg
- jpg
- pbm
- pgm
- png
- ppm
- tiff
- xbm
- xpm

## Icon bar

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The icon bar provides control element shortcuts for the most important and common functions.



Read on for further explanation:

- [New tab, text, table](#)
- [Create new item](#)
- [Open](#)
- [Browse](#)
- [Import movie](#)
- [Save](#)
- [Print](#)
- [History](#)
- [Zoom](#)
- [Color gradient](#)
- [Advanced settings](#)
- [Display properties](#)
- [General settings](#)
  - [Memory management](#)
  - [History and directories](#)

### New tab, text, table



enables you to create

- a new page in the tabulator view
- a new text for storing your notes
- a new table.

Every tab gets a default name, but can be renamed.

### Create new item

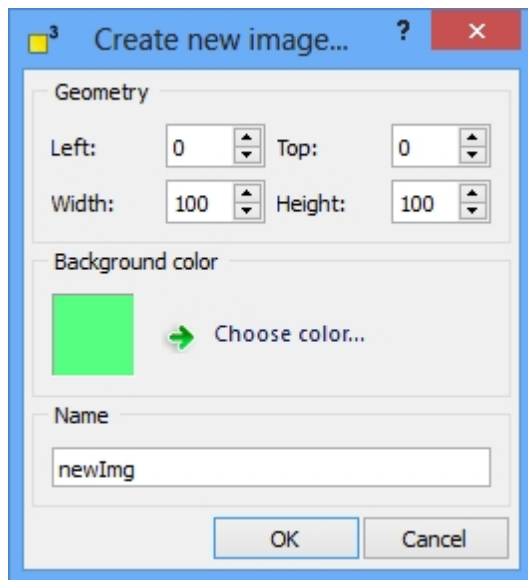


creates a new item which can be used as an artificial image with all its [layers](#): z matrix, picture, object and mask layer. An exemplary application is the creation of presentation slides.

Define

- position
- color and
- name

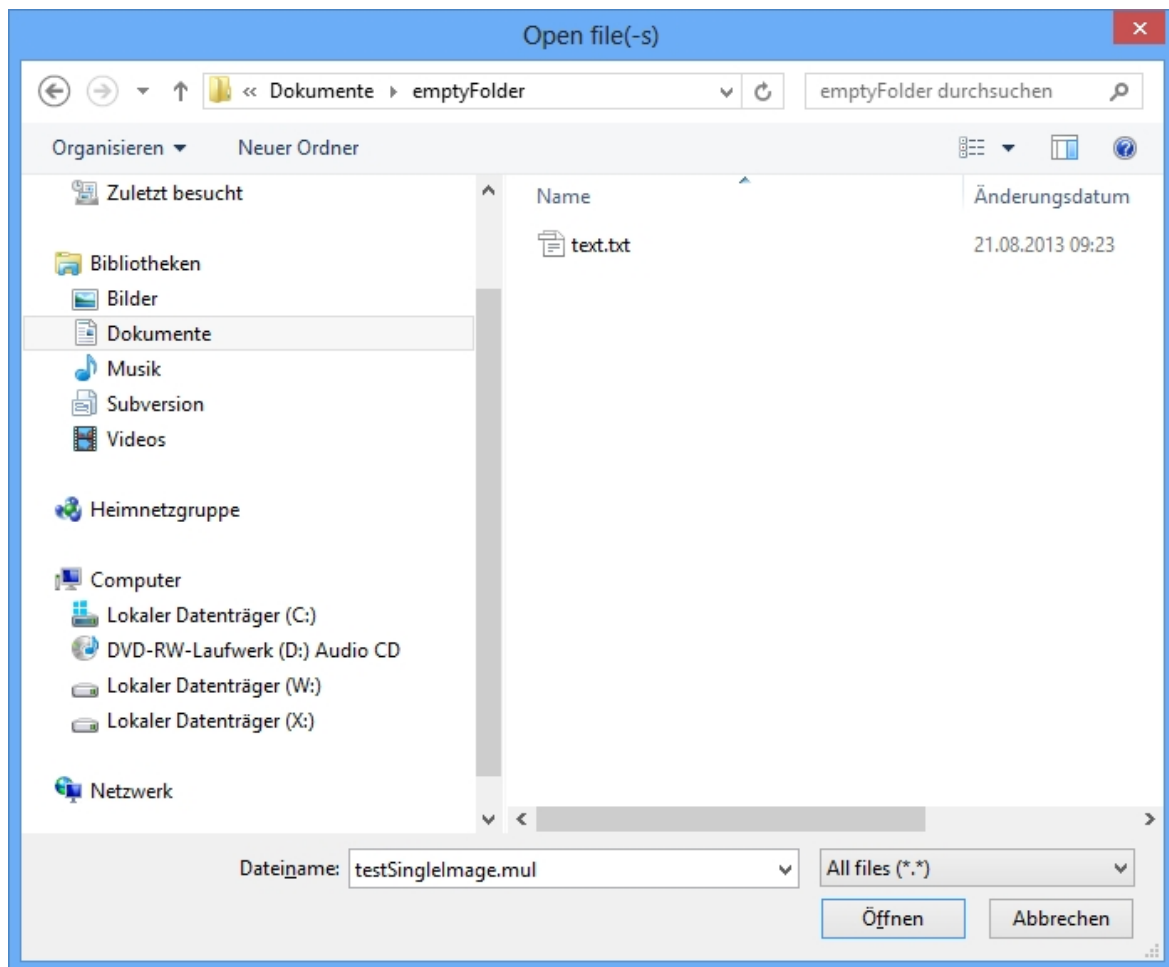
in the creation dialog.



## Open



opens any file dotCube is able to read. Apply one of the default file type filters for an easier selection. See for further options the [open file details dialog](#).



## Open file details dialog

The open file details dialog is shown anytime an image is loaded. Within this dialog, the

- alignment
  - color gradient
  - display settings
- are specified.

## Alignment

The alignment options control how the newly loaded images are arranged on the current collection tab. Define

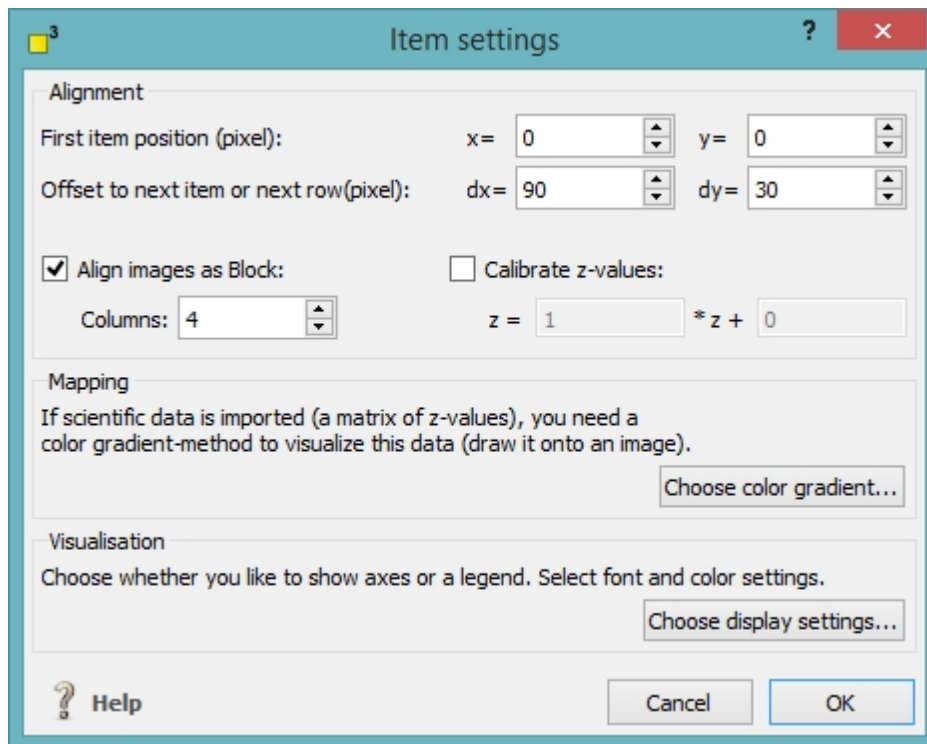
- the position of the first item
- left spaces between the images in x and y direction
- if the images should be organized in columns
- if the image data should be recalibrated

## Color gradient

The color gradient option defines how the image data is visualized. For detailed description see the "[Color gradient](#)" chapter.

## Visualization

The visualization dialog provides many possibilities to add useful accessories to images like a scale bar, ruler and more. For further details read the chapter "[Display properties](#)".



## Browse



The "Browse Files" option features a gallerylike view of your data. Use this dialog to browse through your data files, see a preview of any file dotCube is able to read and select your favorite images easily. The [plane correction](#) and [derivative](#) options enhance the visibility and hence speed up the image selection.

## Select folder and start scan

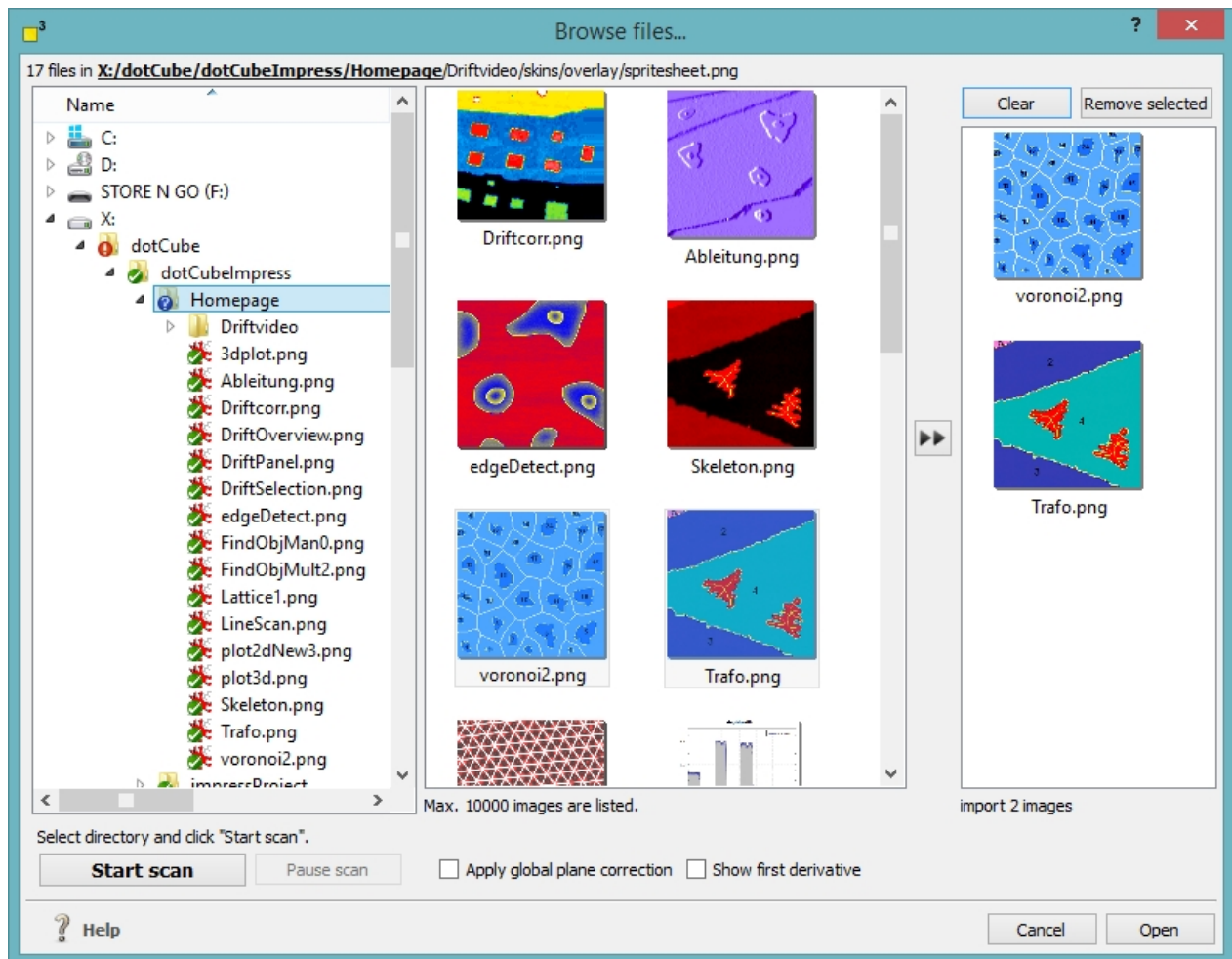
The left panel provide the option to select a folder which should be scanned. Select one and click the "Start scan" button. Once the whole content of the selected folder is read, the scan stops automatically. Consider activating the [plane correction](#) or [derivative](#) options if you expect tilted or curved image data to enhance the visibility. Press the "Pause scan" button to abort the scan procedure.

## Evaluate scanned image data

The middle panel displays a gallery view containing scanned images of the previously selected folder. Select one or more images and click onto the button with double arrows to move your selected items into the import panel view. If the image browser is reading text files, the selection of images will be much easier if you pause the scan procedure like explained above.

## Import data

The right panel displays the images which will be imported. To remove an image, select one and press the "Remove selected" button. To empty the entire import panel view, press the "Clear" button. For starting the import procedure, press the "Open" button.



## Import movie

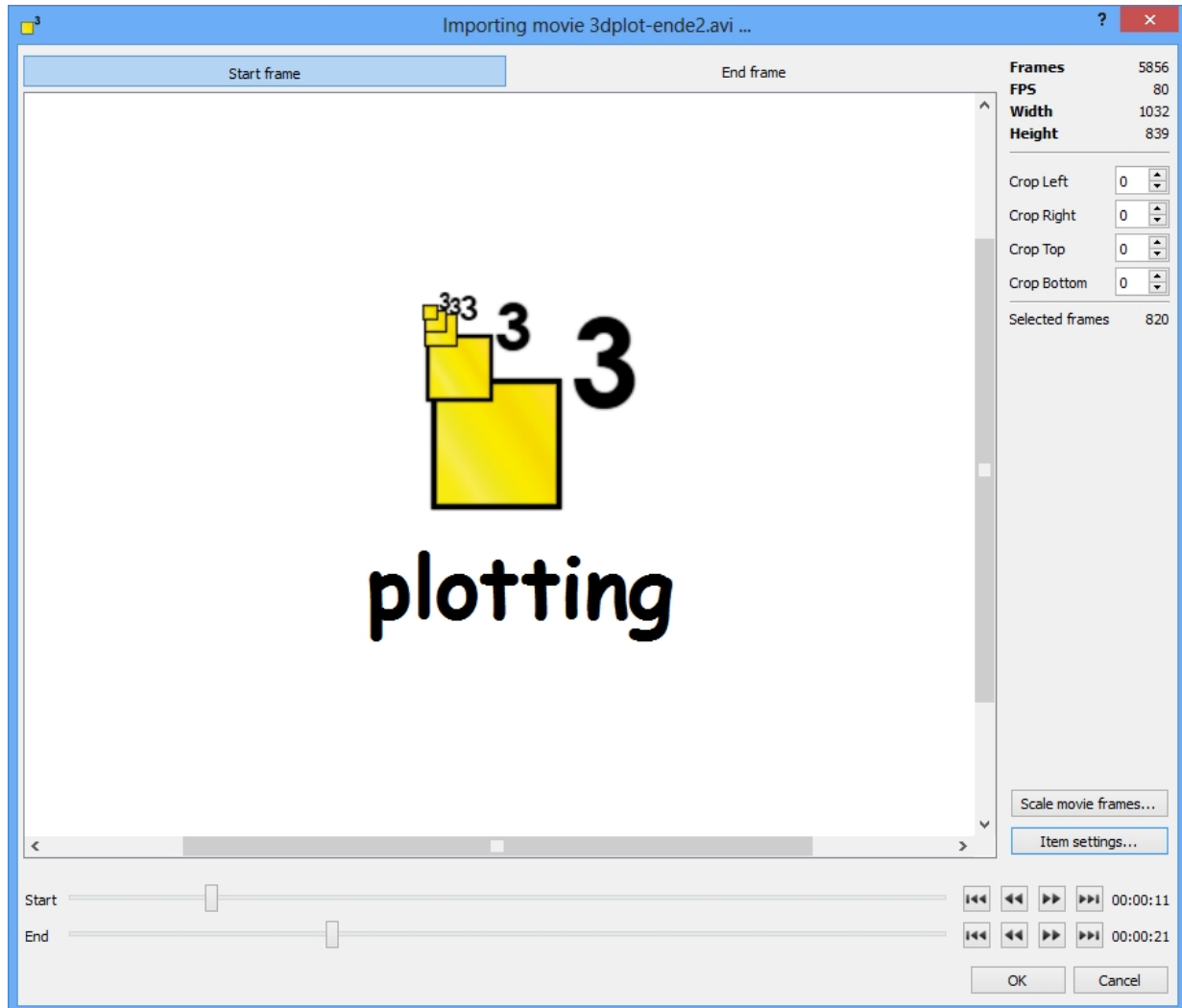


dotCube supports working with movies (\*.avi, \*.mp4, \*.mov) and animated image files (\*.gif). Select your favorite movie file in the open file dialog. Once a file is selected, the movie import dialog offers extensive functionality to pick the frames of your interest.

Read on for further details:

- [Frames selection](#)

- [Crop images](#)
- [Scale images](#)
- [Item settings](#)



## Frames selection

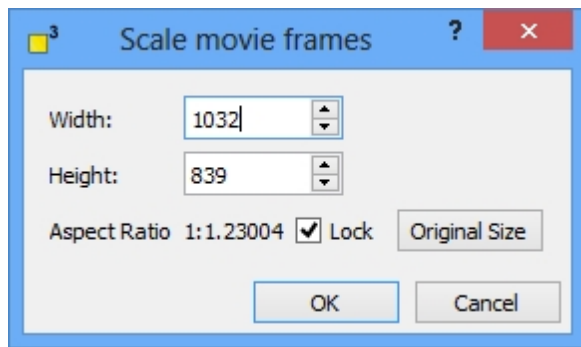
Adjust the "Start" and "End" sliders to preselect a movie part. Use the arrow buttons on the right to select the next frame or key frame. To display the first and / or last frame, click on the "Start frame" and "End frame" buttons.

## Crop images

The image dimensions are shown on the right upper side of the import dialog. Specify the pixel you would like to crop below.

## Scale images

dotCube provides the ability to scale the imported movie frames. Click on the "Scale movie frames..." button and define your new image dimensions.



## Item settings

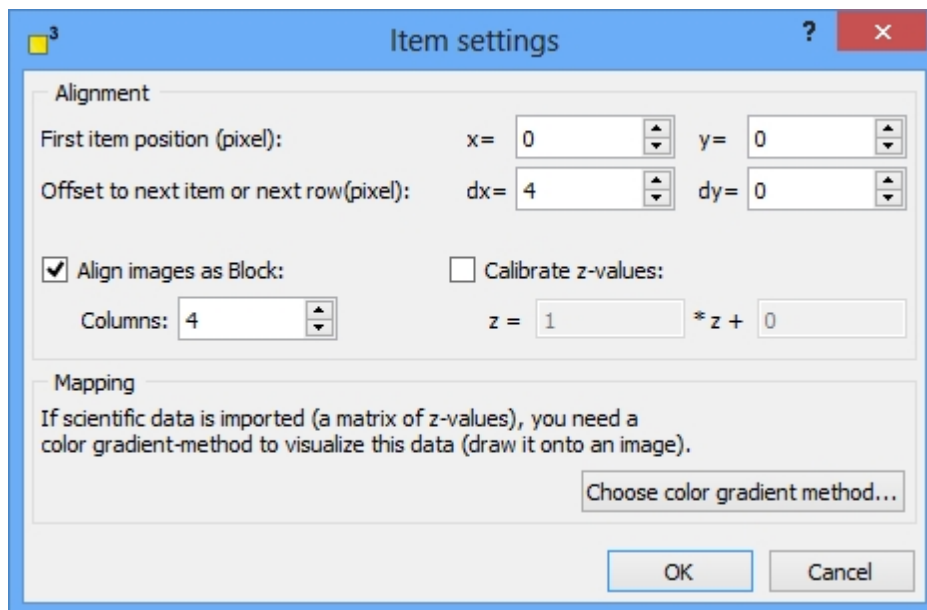
The item settings dialog provides the presets for

- alignment of the imported frames,
- the z calibration and
- their color mapping.

Decide if the images should be stacked or arranged block wise with or without space in between.

To recalibrate the z values, check the "Calibrate z-values" option and insert the applicable factors. You might calibrate the z matrix later using the [right click](#) or "Edit" menu.

Select your favorite color settings to map the z matrix by clicking on the "Choose color gradient method..." button. For further details see the [color gradient](#) section.

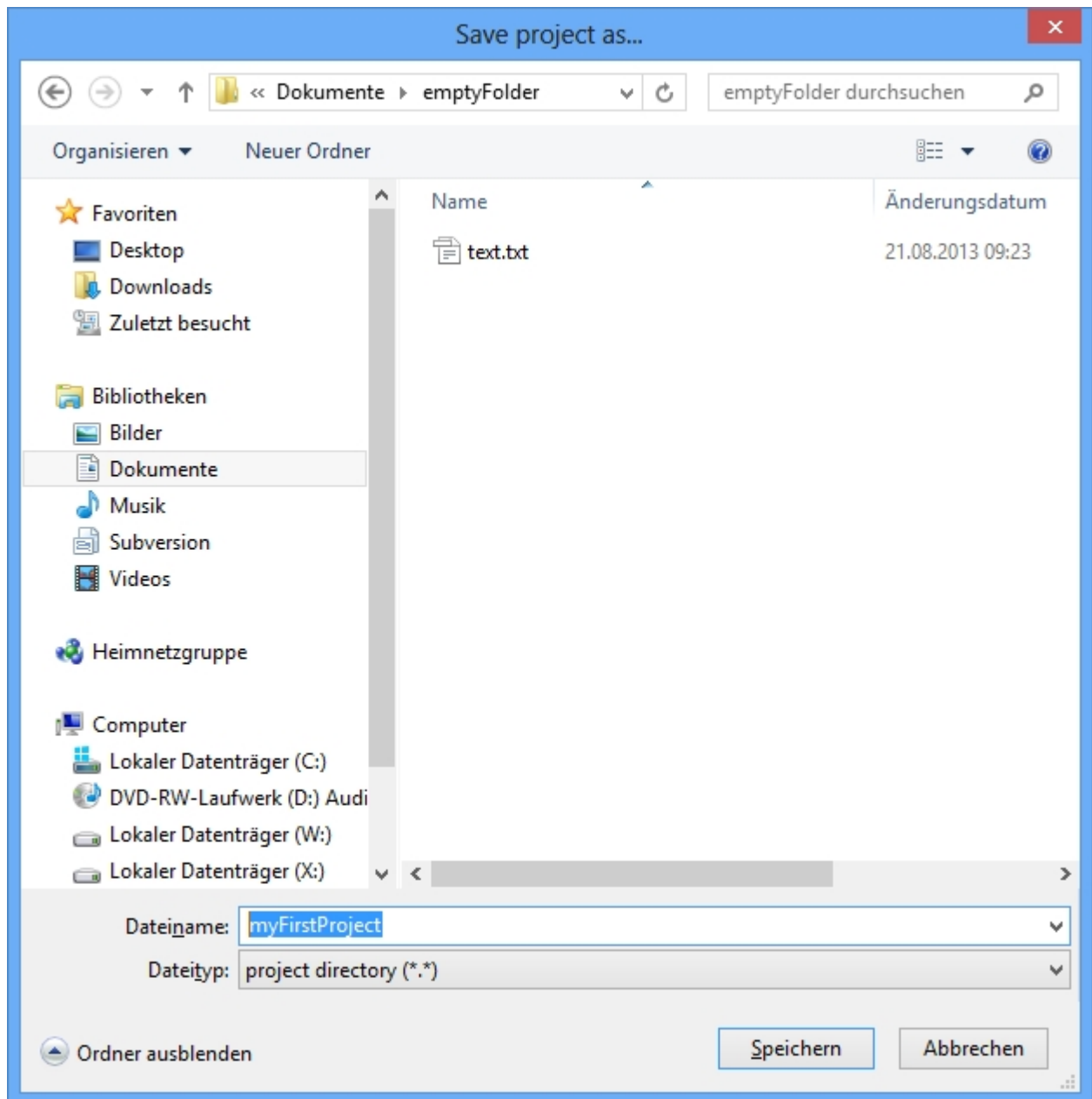


## Save



For saving a project, selected images or the images on the current tab, click on the "Save" button. Name your file and save it.





## Print



prints the visible area of the current collection. Use the [zoom](#) function to adjust the scaling.

## History



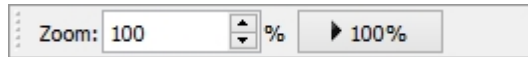
Activate the history function, if you want to be able to revert actions. The button is blue colored if activated. The presets of the history functions are set in the [general settings](#) dialog.

To proceed steps backwards or forwards, use the left or right button.



## Zoom

Adjust the zoom level by turning the mouse wheel or by changing manually the zoom factor in the [icon bar](#). To return to the "100%" default value, click the "100%" button.



## Color gradient



The color gradient translates the numerical statement of the z matrix into a visual presentation and vice versa. Dependent on the current color gradient method, features may appear more or less emphasized.

Read on for further details:

- [Color method](#)
- [Translate picture data into z data and vice versa](#)
- [Select a default color gradient](#)
- [Color defining options](#)
- [Save custom gradient](#)

## Color method

The color gradient transforms heights in colors. Thereby, the extreme values (minimum and maximum z values) are determined. The color gradient function assigns each height range of an image to a color range and expresses the exact height by varying the hue value of the current color.

## Translate picture data into z data and vice versa

When [loading native image files](#) like \*.bmp and similar, the color gradient has to determine heights from the color distribution no matter if the image is a monochrome or colored one. Therefore, independent from the color, the hue value is converted into z values which define the image heights.

The [right-click menu](#) in the main window contains the [mapping options](#) in both directions under the caption "[z matrix](#)": map picture data to z values as well as map z values to picture (see the [collections](#) / [right-click menu](#) chapter).

## Select a default color gradient

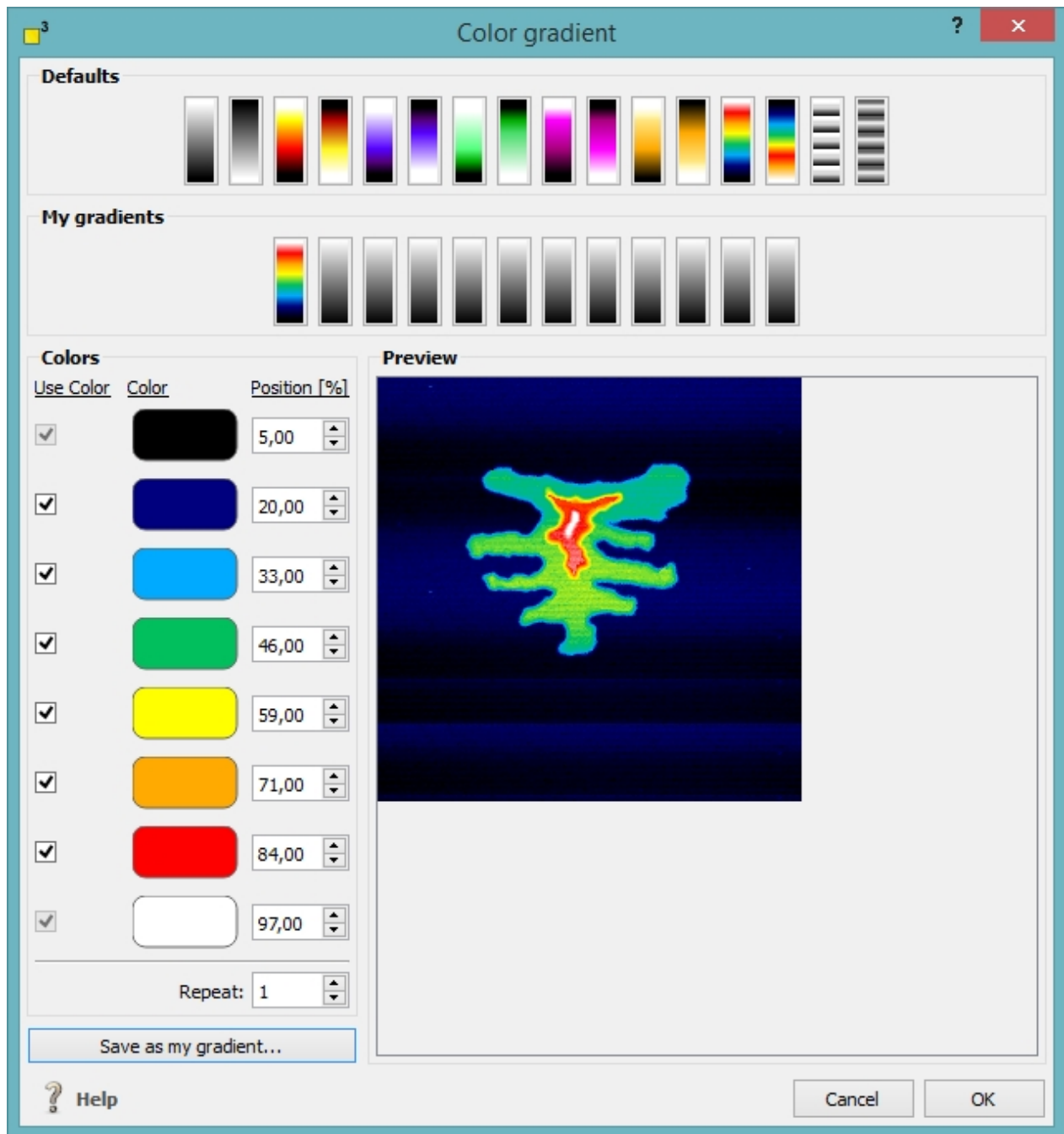
The uppermost section of the color gradient dialog displays a collection of color gradient presets. They are applied to an image by clicking on one of them.

## Color defining options

The color panel on the left of the color gradient dialog contains the setting options of the current selected color gradient. Each color can be employed or deployed by activating or deactivating each color checkbox. By clicking of a distinct color you might modify each one. The position values state which height level of the total image height is painted with the current color. The repeat option at the bottom of the color gradient dialog defines how often the current color gradient is looped within the overall height of the image.

## Save custom gradient

After a default color gradient is modified or a new color gradient is defined, the current settings can be stored. Just click on the "Save as my gradient..." button at the bottom of the dialog and choose a gradient representation in the "My gradients" sections.



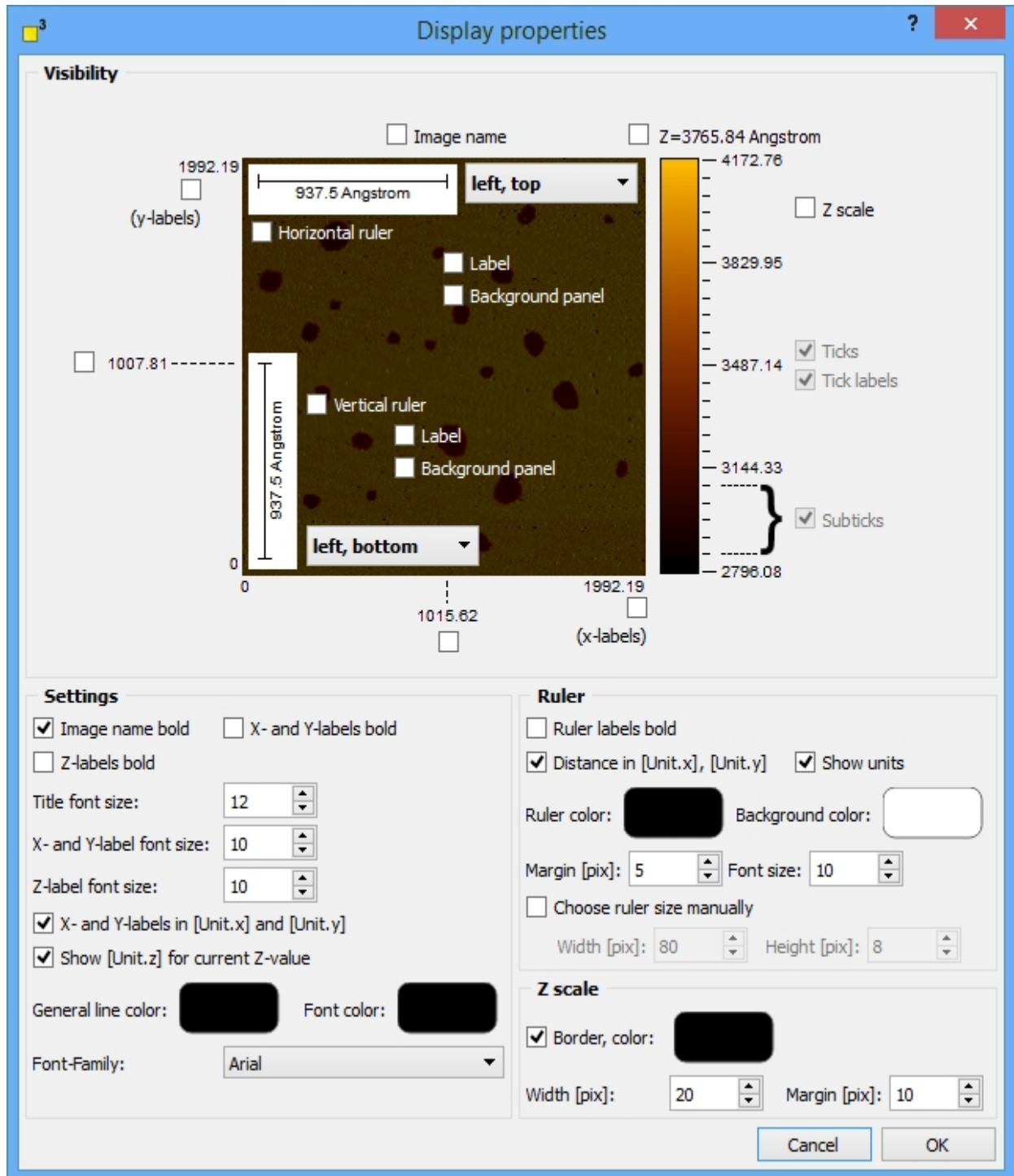
## Display properties



The display properties provide the possibility to add helpful accessories to your images. You might add a z scale legend as well as rulers and labels. Select the applicable items and define their presets.

Available accessories are:

- Horizontal ruler
- Vertical ruler
- Image title
- X and y labels
- Z scale legend
- Image coordinates on mouse move



## Advanced properties

The advanced properties menu displays the entire image header values. These values originate from three different sources:

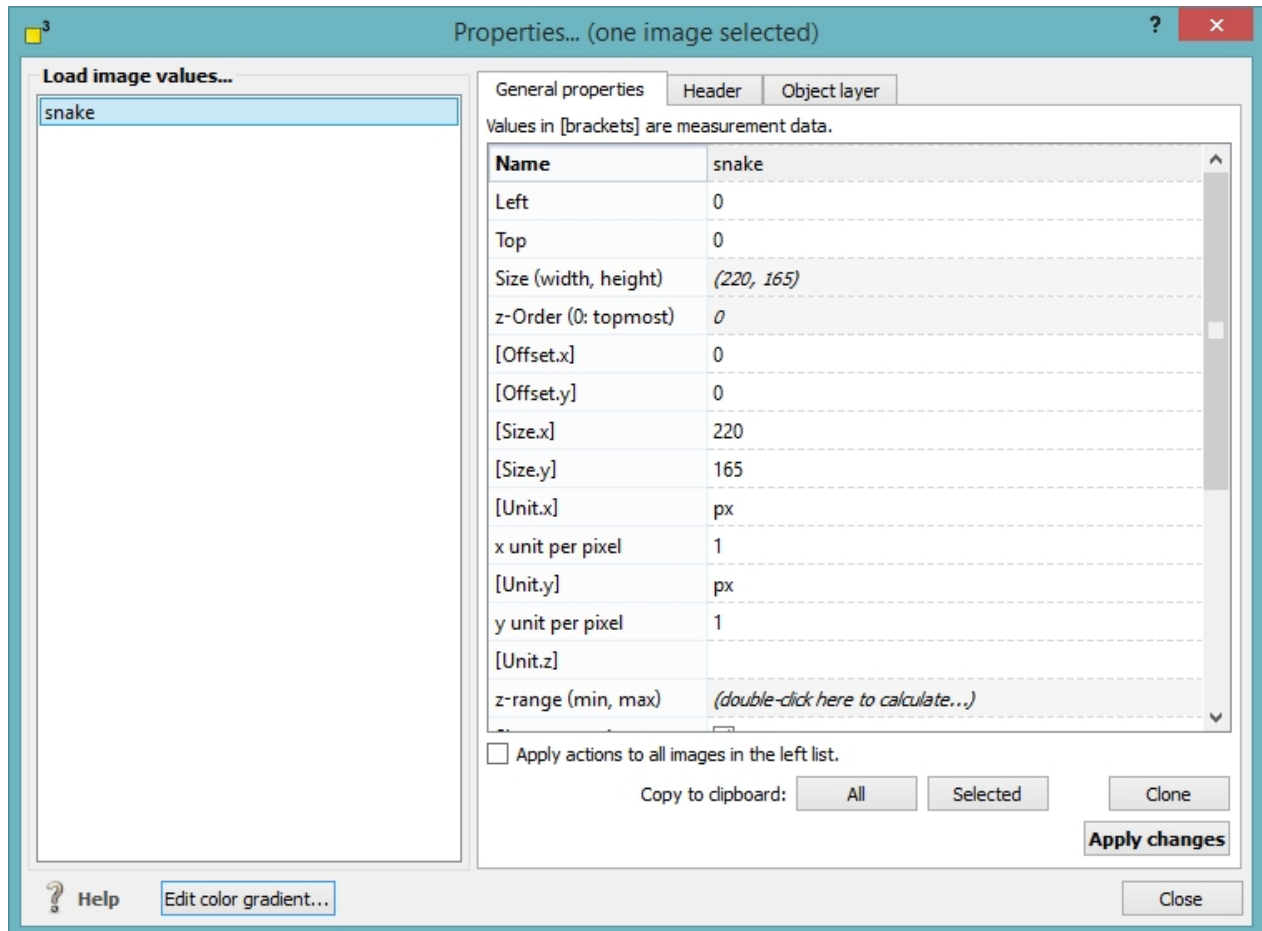
- The general properties page displays the header values written by the dotCube software.
- The header page shows the values written by your measurement device.
- The object layer page contains found objects and their properties.

The advanced properties dialog enables the user to modify these values and copy them to clipboard. Decide, if you would like to apply your modifications to - or copy values to clipboard from

- the current image
- any selected images displayed in the left panel.

The "Copy to clipboard" functions offers access to text-formatted header values.

**Important:** To **check or uncheck** header values or objects will only change their **visibility status**. To select a header value or an object you have to select the entire data cell.



## General settings



The general settings dialog provides the basic presets for dotCube for

- [License](#)
- [History](#)
- [Memory management](#) and
- [Other \(directory settings\)](#).

## License

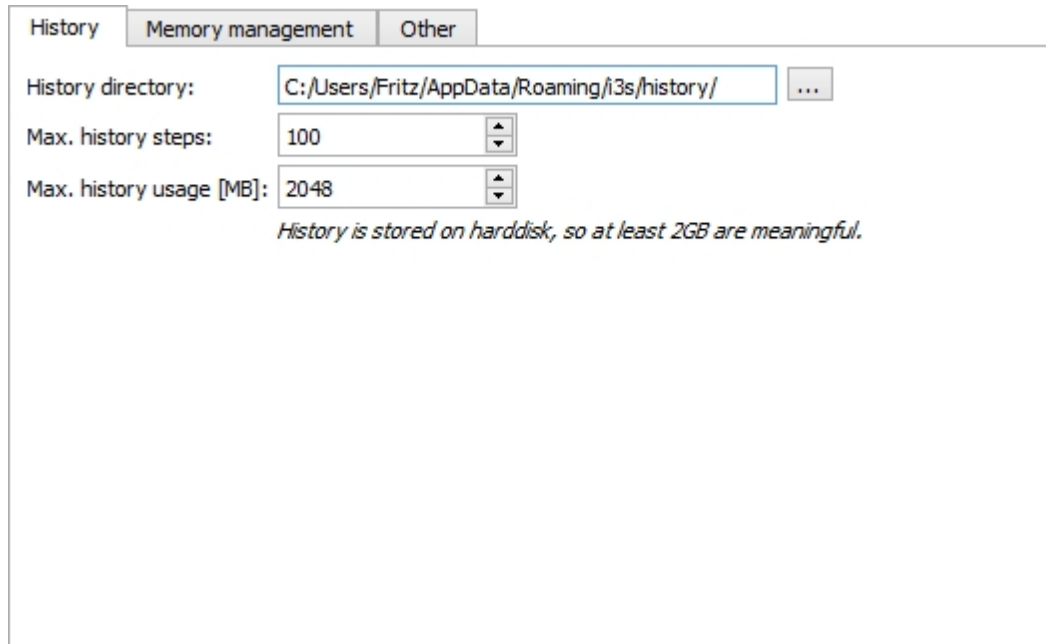
The license type is set in the license tabular dialog. Two possible licenses are available: An educational version for free and professional ones. Select the appropriate option and insert your license key and number for professional licenses. Click the buttons below to visit our web shop or contact us.

A short introduction to dotCube is displayed if you press the "Show introduction" button.

## History

Define the directories, the maximum steps and the maximum storage in the history tab. For further details

about the history function, see the [history](#) section in the [icon bar](#).



History   Memory management   Other

History directory:  ...

Max. history steps:

Max. history usage [MB]:

*History is stored on harddisk, so at least 2GB are meaningful.*

## Memory management

The Swap options are set on the memory management page. Select the

- directory and the
- minimum RAM usage.

When you are working with large amount of items, an item limit per tab may be useful. This enables you to swap currently not needed items.

You might swap

- items placed on any than the current tab
- invisible items
- any z matrices
- any background images.

When you are working with the z matrices (e.g.: [image processing](#) functions), swapping of z matrices will increase the computation time. Hence, to swap the background images might be the better choice in this case dependent on your RAM occupancy. The draw functions (e.g. "[draw](#)" in the [scientific tool bar](#)) will work with the image layers. Thus, you should not swap the background images if not necessary.

History Memory management Other

Swap directory: C:/Users/Carsten/AppData/Roaming/t3s/swap/ ...

Swapping only starts when the following amount of RAM is occupied by ALL running programs.

Min. used memory [MB]: 5251 Use 65% (recommended)

---

If the following number of items on a tab is exceeded a new tab is created.

Max. items per tab: 300

☐ Swap items that are not on the current tab (recommended)

☐ Swap (manually hidden) invisible items (recommended)  
(swapped items appear in gray)

☐ Swap all z-matrices (saves ~50% of RAM but slows down some operations)

☐ Swap all background images (saves ~25% of RAM but crucially slows down operations)  
(partly swapped items appear in blue)

## Other

Dependent on your hardware architecture, using OpenGL might be a good option. When you are working with single very large images, they might appear black if they exceed the storage of your graphics card.

Define directories for temporary, default project and ffmpeg use. The temp directory is used by dotCube for storing large temporary files.

Specify the ffmpeg path if you are planning to work with [movies](#).

History Memory management Other

☒ Use OpenGL in new tabs to render graphics  
*faster display, but system-specific limitations may cause large items to be black*

---

Temp directory: C:/Users/Carsten/AppData/Roaming/t3s/temp/ ...

Default project directory: C:/Users/Carsten/AppData/Roaming/t3s/project/ ...

FFmpeg path: C:/Program Files (x86)/ffmpeg/bin/ Autodetect ...

## Collections

The analyzing playground in the screen center is called "Collections": where you look through your data, play with effects, prepare presentations,... - basically your workbench.

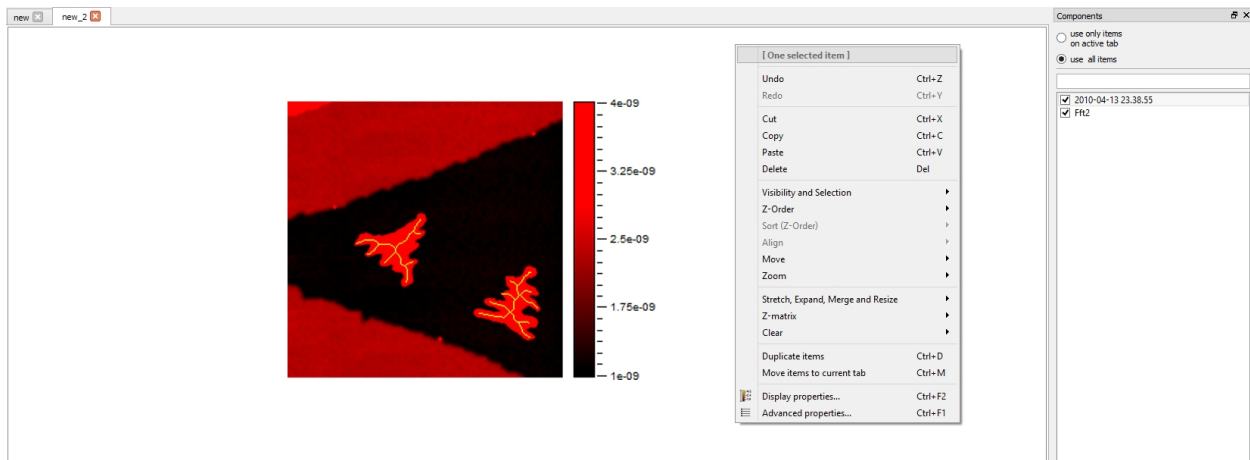
The major instruments for working here are the

- [Tabulator view](#)



- [Components list](#)
- [Right click menu](#) - similar to the "Edit" menu in the menu bar

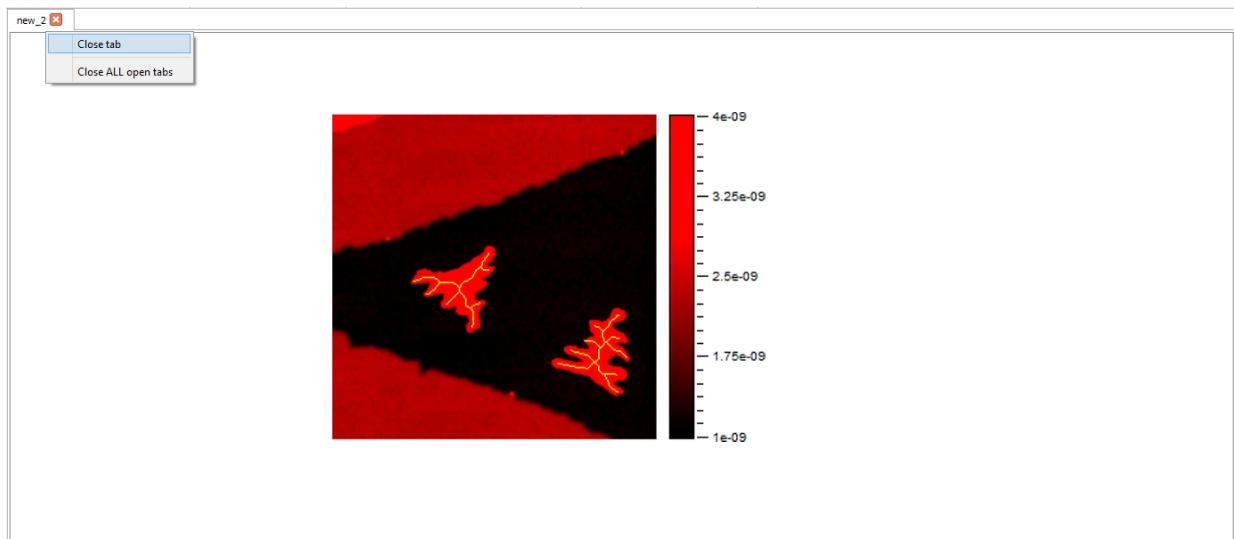
For shortcut keys we refer to our [detailed list](#).



## Tabulator view

The tabulator view offers space for working with your data. It can be extended without limits in x and y direction (depending on your hardware). Furthermore, several tabulator pages can be created to arrange your data in a suitable way.

- click and drag the images to arrange them in your way (see the [cursor](#) section)
- [zoom](#) in or out by turning the mouse wheel or adjust the zoom factor in the task menu
- each component of one or the entire pages is listed in the [components](#) list
- press CTRL and "t" to open a new page (or use the task menu: File - [New](#) - Tab)
- use the tab close dialog for closing a single or the entire pages



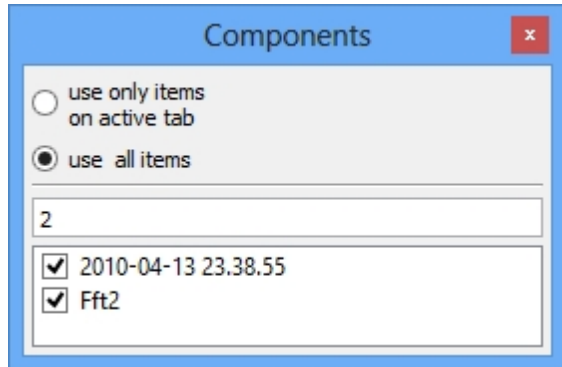
## Component list

The component list helps you to get a general view of any items and organize your data.

- Select your display setting: list items on active [tab](#) or all items
- Filter your items by inserting a filter rule
- Check or uncheck each item to switch the visibility on or off
- Select an item by clicking on its label

- Press CTRL and click on labels to select multiple items
- CTRL and "a" will select all items
- Click and drag labels to change their z order (move to front or rear)



**Note:** The visibility of your items and their tab arrangement might influence the memory management of your hardware. See the [memory management](#) page in the icon bar chapter.



## Right click / Edit menu

This menu provides elements to control

- [History](#)
- [Porting items](#) - cut, copy, paste, delete
- [Visibility, selection, alignment and motion](#)
- [Working with items and their layers](#)
  - [Image layers](#)
  - [Ordinates](#)
  - [Recalibration of z values](#)
- [Display properties](#)
- [Advanced properties](#)

[ One selected item ]		
Undo		Ctrl+Z
Redo		Ctrl+Y
Cut		Ctrl+X
Copy		Ctrl+C
Paste		Ctrl+V
Delete		Del
Visibility and Selection		▶
Z-Order		▶
Sort (Z-Order)		▶
Align		▶
Move		▶
Zoom		▶
Stretch, Expand, Merge and Resize		▶
Z-matrix		▶
Clear		▶
Duplicate items		Ctrl+D
Move items to current tab		Ctrl+M
 Display properties...		Ctrl+F2
 Advanced properties...		Ctrl+F1

## History

If the history is [activated](#), the "Undo" option reverts every action. In contrary, the "Redo" function recapitulates each reverted action until the origin status is reached.

## Porting items

The "Cut" option copies and removes the currently selected items into the clipboard which **only in this case** can exclusively be accessed from dotCube. Use the "Paste" function to place the items from the clipboard onto the current tabulator page.

To copy without removing anything, use the "Copy" function.

"Delete" erases any selected item.

## Visibility, selection, alignment and motion

Headline	Function	Description
<i>Visibility and selection</i>	<i>Show</i>	Selected items are set visible.
	<i>Hide</i>	Selected items are set invisible.
	<i>Select all</i>	Any item on any tab is selected.
	<i>Deselect all</i>	Any item on any tab is

		deselected.
	<i>Toggle selection</i>	Inverts the current selection.
<i>Z order</i>	<i>Bring to front</i>	The selected item is placed above any other selected one.
	<i>Send to back</i>	The selected item is placed under any other selected one.
	<i>Stack under first item</i>	The selected item is placed below the topmost selected one.
	<i>Stack onto last item</i>	The selected item is placed above the lowest selected one.
	<i>Revert order</i>	The item z order is put upside down.
<i>Sort (z order)</i>	<i>By name</i>	The selected items are sort in alphabetical order.
	<i>By creation time</i>	The selected items are sort in respect to their creation in dot cube.
	<i>by number in name</i>	Alphabetic characters are ignored. The selected items are sort in numerical order (e.g.: "img1" is placed above "img10").
<i>Align</i>	<i>Top</i>	Places any selected item to the y position of the topmost item.
	<i>Right</i>	Places any selected item to the x position of the rightmost item.
	<i>Bottom</i>	Places any selected item to the y position of the bottommost item.
	<i>Left</i>	Places any selected item to the x position of the leftmost item.
	<i>Centered</i>	Stacks every selected item in the center.
<i>Move</i>	<i>Move one pixel up</i>	Shifts selected items one pixel upwards.
	<i>Move one pixel right</i>	Shifts selected items one pixel rightwards.
	<i>Move one pixel down</i>	Shifts selected items one pixel downwards.
	<i>Move one pixel left</i>	Shifts selected items one pixel leftwards.
	<i>Move eight pixels up</i>	Shifts selected items eight pixels upwards.

	<i>Move eight pixels right</i>	Shifts selected items eight pixels rightwards.
	<i>Move eight pixels down</i>	Shifts selected items eight pixels downwards.
	<i>Move eight pixels left</i>	Shifts selected items eight pixels leftwards.
<i>Zoom</i>	<i>Zoom in</i>	Increases zoom by 10%.
	<i>Zoom out</i>	Decreases zoom by 10%.
	<i>Reset zoom (100%)</i>	Sets zoom to 100%.

## Working with items and their layers

Each image contains four stacked layers: From bottom to top:

- Z matrix layer - consists of your measurement data
- Picture layer - implicates any drawing
- Object layer - contains found objects
- Selection / mask layer - implies selected pixels.

The layers contain different origins of ordinates:

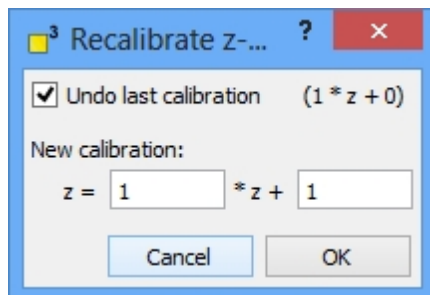
- origin of ordinates on the left top side: picture, object and selection layer
- origin of ordinates on the left bottom side: z matrix layer.

The "Clear" function enables the user to erase anything of the picture, object or mask layer. For solely editing the

- Z matrix layer, use the "[Z matrix manipulation](#)" tool,
- Picture layer, use the [draw](#) options in the scientific tool bar or the "[Edit object](#)" tool,
- Object layer, use the "[Edit object](#)" tool or the "[Advanced Properties](#)" menu in the right click or "Edit" menu,
- Mask layer, use the "[Edit object](#)" tool or the [selection](#) section of the scientific tool bar.

The interplay between picture and z matrix layer is controlled by the "Z-Matrix" mapping functions. These functions enable you to map the picture data to the z matrix layer or map the z data to the picture layer.

To recalibrate the z matrix, use the "Recalibrate z matrix" function and define the calibration factors. You might revert the last calibration settings which are shown in the upper dialog section.



For changing the color gradient, select "color gradient". [This dialog](#) is explained in detail in the [icon bar](#) chapter.

"Duplicated items" copies and pastes the selected items.

"Move items to current tab" cuts the selected items and pastes them onto the current tab.

## Display properties

See [display properties](#) in the [icon bar](#) chapter.

## Advanced properties

See the [advanced properties](#) section in the [icon bar](#) chapter.

## Scientific tool bar

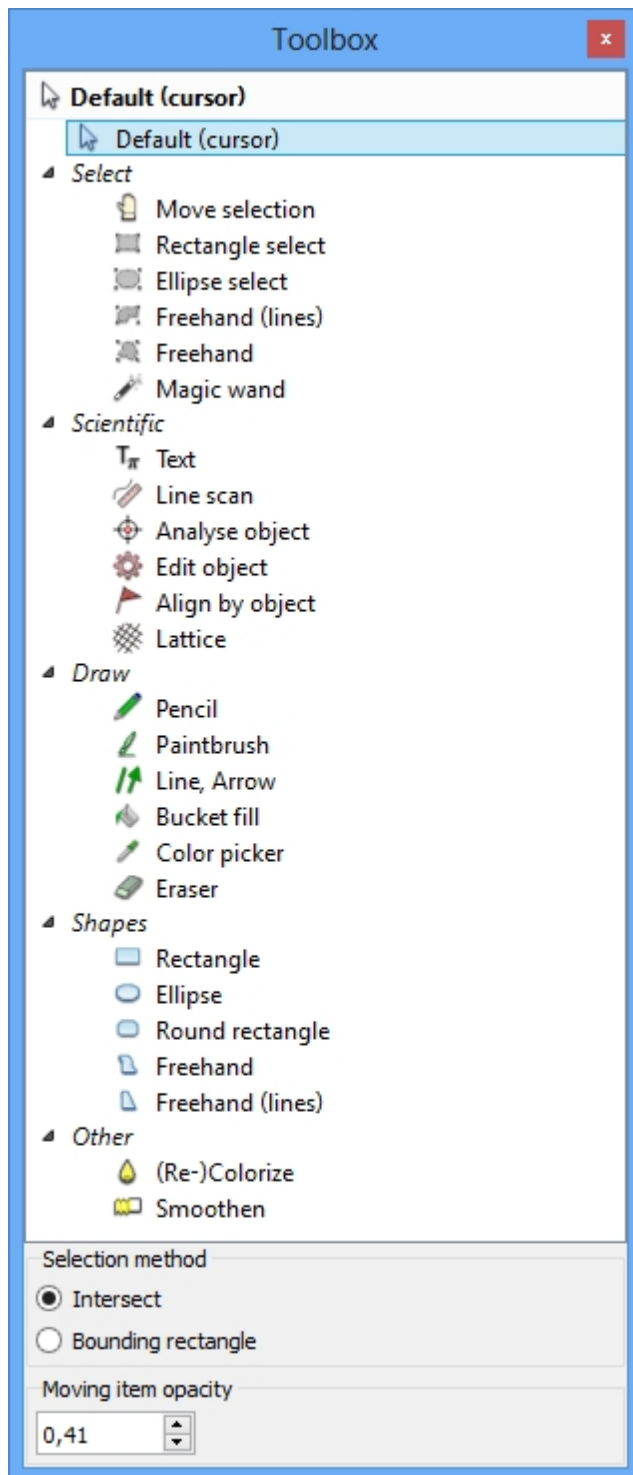
---

The scientific tool bar provides a extensive and powerful repertory for marking, analyzing and drawing easily and fast.

**Note:** If you select multiple images, the tools will be applied to all of them. It is the dotCube concept of working with large data bundles on the fast-track. Keep in mind the different [origins of ordinates](#).

See detailed explanation:

- [Default cursor](#)
- [Select](#)
  - [Move selection](#)
  - [Rectangle select](#)
  - [Ellipse select](#)
  - [Freehand \(lines\)](#)
  - [Freehand](#)
  - [Magic wand](#)
- [Scientific](#)
  - [Text](#)
  - [Line scan](#)
  - [Analyse object](#)
  - [Edit object](#)
  - [Align by object](#)
  - [Lattice](#)
- [Draw](#)
  - [Pencil](#)
  - [Paintbrush](#)
  - [Line, Arrow](#)
  - [Bucket fill](#)
  - [Color picker](#)
  - [Eraser](#)
- [Shapes](#)
  - [Rectangle](#)
  - [Ellipse](#)
  - [Round rectangle](#)
  - [Freehand](#)
  - [Freehand \(lines\)](#)



## Default cursor

The default cursor is the tool to mark, move and select things in dotCube. Two selecting methods are available:

- Intersect: Any object whose border is crossed by the marking rectangle will be selected.
- Bounding rectangle: Only objects which are fully encircled are selected.

The opacity of images during their moving is adjustable by the "Moving item opacity" option. Valid values ranges from "0" to "1".

**Tip:** To correct drift in images manually, set the opacity to "0.5". The transparent option enables you to stack your images exactly and export them drift corrected as a [movie file](#).



The screenshot shows two UI elements. The first is a 'Selection method' section with two radio buttons: 'Intersect' (which is selected) and 'Bounding rectangle'. The second is a 'Moving item opacity' section with a text input field containing '0,41' and a small vertical slider control to its right.

## Select

The selection tools repository contains extensive tools to assist you during various selection processes and makes handling and adjusting of selections easy and fast. For shortcut keys we refer to our [detailed list](#).

**Note:** The selection tools will work only within an image.

See detailed explanation:

- [Move selection](#)
- [Rectangle select](#)
- [Ellipse select](#)
- [Freehand \(lines\)](#)
- [Freehand](#)
- [Magic wand](#)

## Move selection

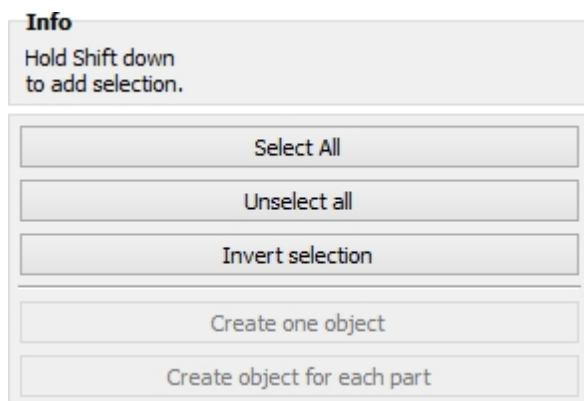
Once something is selected, the "Move selection" tool enables you to shift your marked area. Just grab the selection with the mouse and move it.

## Rectangle select

With the activated rectangle select option, pixels are selected with a rectangular shape.

The selection options are:

- Select all: Selects every image pixel
- Unselect all: Unselects any selected pixels
- Invert selection: Previously selected pixels will set unselected and vice versa



The screenshot shows an 'Info' panel with a header 'Info' and a sub-header 'Hold Shift down to add selection.' Below this are five buttons stacked vertically: 'Select All', 'Unselect all', 'Invert selection', 'Create one object', and 'Create object for each part'.

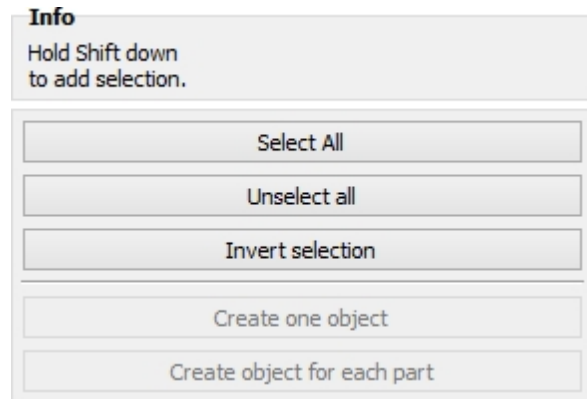
## Ellipse select



With the activated ellipse select option, pixels are selected with a elliptical shape.

The selection options are:

- Select all: Selects every image pixel
- Unselect all: Unselects any selected pixels
- Invert selection: Previously selected pixels will set unselected and vice versa

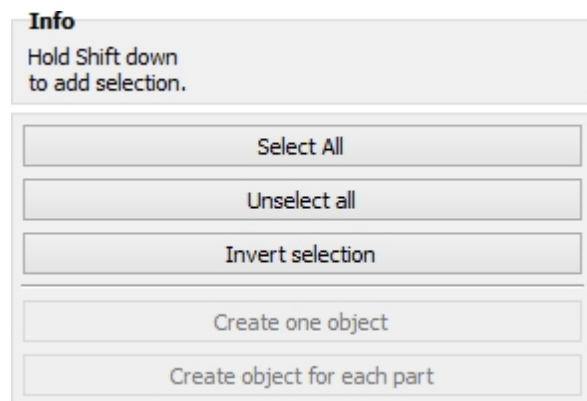


## Freehand (lines)

With the activated freehand (lines) select option, pixels are selected within a closed customized shape. Click and move the mouse to draw the selection lines. Click and move again for further lines. When you click on a previously drawn selection line, the selection figure border will be closed and any pixel within will be selected.

The selection options are:

- Select all: Selects every image pixel
- Unselect all: Unselects any selected pixels
- Invert selection: Previously selected pixels will set unselected and vice versa

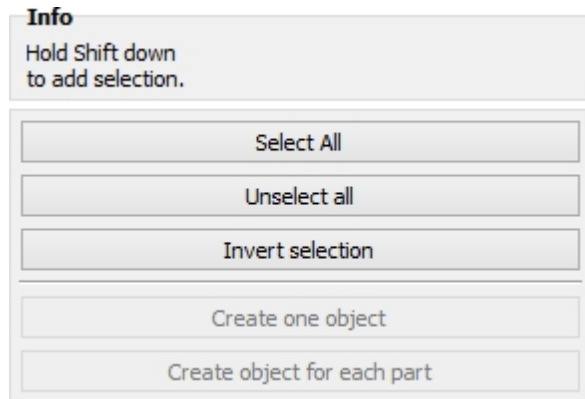


## Freehand

With the activated freehand select option, pixels are selected within a closed customized shape. Click, hold and move the mouse for building up the selection. The selection will be finished when you release the left mouse button.

The selection options are:

- Select all: Selects every image pixel
- Unselect all: Unselects any selected pixels
- Invert selection: Previously selected pixels will set unselected and vice versa



## Magic wand

Magic wand is a powerful tool for selecting automatically complicated but similar structures. Similar means in this case either similar colors or similar z values (heights). Once a structure is selected, the entire collection of image analysis features are at your disposal. For example, the function "Transform selection into object" converts the current selection into an object and enables you to use the extensive object property selection for further analysis.

Read on for a detailed description:

- [How does the magic wand tool work?](#)
- [Processing different image layers](#)
- [Defining the tolerance](#)
  - [Example: Variation of the tolerance limits](#)
- [Adding points to current selection](#)
- [Restrict magic wand to former selection](#)
- [Select in inverse order](#)

## How does the magic wand tool work?

The magic wand selection process begins with a click on a previously selected image. From this starting point, any pixel is selected which

- has a similar z value or color
- is connected contiguously to a previously selected pixel.

In this way, similar and contiguous pixels are selected and form the selection result.

## Processing different image layers

The magic wand tool processes two kinds of layers:

- the picture layer or
- the z layer of images.

In the first case, colors within a user defined range are selected where in the latter case, heights respectively z values are selected.

## Defining the tolerance

Two range defining options are available: percentual or absolute. The percentual defined tolerance option processes both image and z layer. Thereby, contiguous pixels within the upper and lower range of the start pixel will be allocated to the current selection. The absolute z value option processes z values only.

Thereby, only contiguous pixels within the specified z value range will be allocated to the current selection.

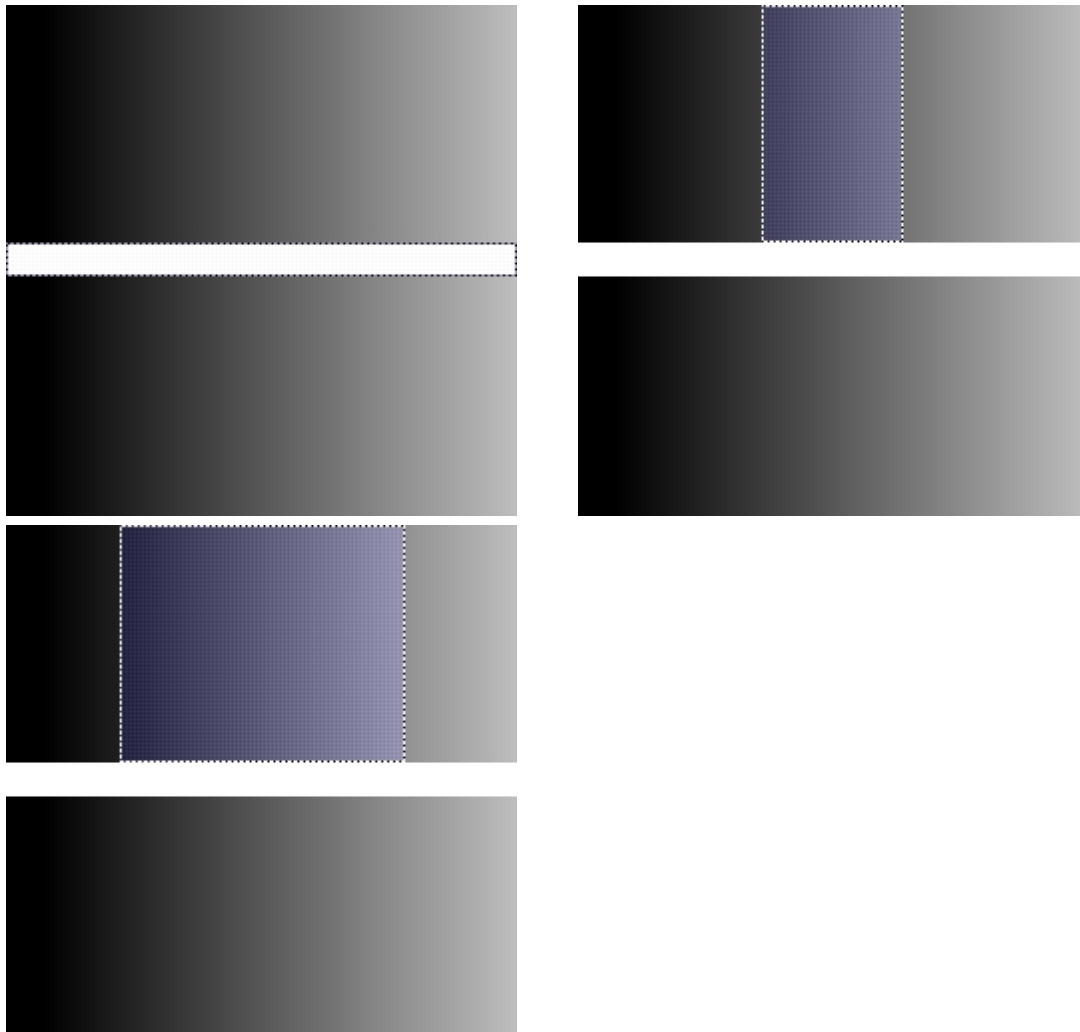
For an easy definition of the z value range, you might use the buttons on the right to define the z value upper

and lower limits by clicking inside an selected image on an upper and lower image part. The so selected limits are automatically inserted into the magic wand settings dialog.

### Example: Variation of the tolerance limits

Let's see how the specified range influences the selection result:

In the first image, we start the magic wand process by clicking into a region of similar colors and z values - the white middle part of the image. The specified magic wand settings allow a tolerance of 10 percent. Hence, this results in a selection of the entire bright and prominent part in the middle of the image. As a next step, we start the magic wand tool from a gray scale region in the upper part of the second image. Around this starting point, every pixel is allocated to a selection which is connected to a previously selected pixel and exhibits a color respectively a z value within 20 percent of the start pixel value. If we increase the tolerance by a factor of 2, we get a selection in the third image which contains twice the size of the former selected gray scale region.



### Adding points to current selection

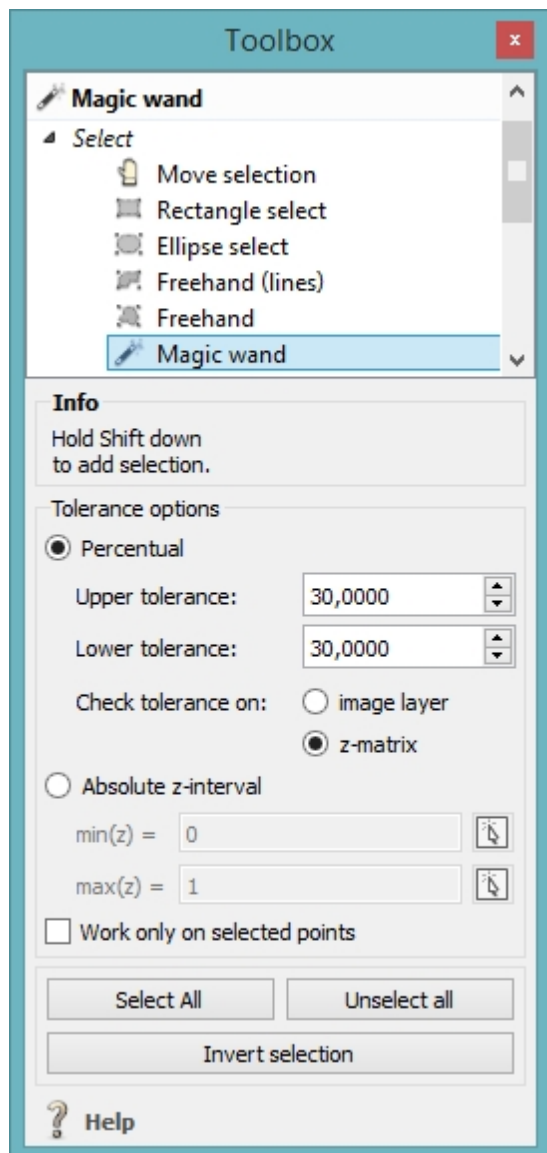
The results of consecutive magic wand processes may be combined by holding the shift key. Every pixel of the last magic wand execution will be added to the former selection.

### Restrict magic wand to former selection

The selection process of the magic wand feature might be restricted to a previously selected region by choosing the "Work only on selected points" option.

## Select in inverse order

Complicated structures surrounded by simple and similar ones might be easily selected by executing the magic wand function in reverse order. Start the magic wand selection on a structure with similar colors and heights, add additional points to the selection if needed (see ["Adding points to current selection"](#)) and press the "Invert selection" button in the dialog window.



## Scientific

The scientific tools repository contains advanced tools to analyze structures and list their properties in tables.

Read on for detailed explanation:

- [Text](#)
- [Line scan](#)
- [Analyse object](#)
- [Edit object](#)
- [Align by object](#)
- [Lattice](#)

## Line scan

The line scan tool performs a definable cut through an image region. Click on the image and move the mouse to draw a line along the features of your interest. On mouse release, the z values may be plotted or tabularized.

Read on for further explanation:

- [Data output](#)
  - [Output settings](#)
    - [Two dimensional plot](#)
    - [Tabular view](#)
    - [Text output and log](#)
  - [Label settings](#)
- [Label options](#)
  - [Pen settings](#)
  - [Cap style](#)
  - [Arrow / line style](#)

Options

☐ **Plot linescan**

☐ Use [Unit.x] for plot and table output

☐ Draw line permanently

Label:

Font-size:

Pen

Size:

☐ Antialiasing

Color:

Cap Style

☐ Round
 ☒ Square

Arrow/Line style

Head size:

## Data output

The line scan function displays the results as a tabular view, a two dimensional plot and / or labels drawn on the image.

### Output settings

If your data format contains natural units, the output in the x direction unit is available by selecting the "use [Unit.x] for plot and table output" option.

### Two dimensional plot

dotCube provides the cut data output as a tabular view and optional as a two dimensional plot. Therefore, select the "Plot line scan" option.

### Tabular view

The line scan data is always displayed in the tabular view. If you prefer natural units, select the "use [Unit.x] for plot and table output" option. The unit preset will be applied to the two dimensional plot, too.

### Text output and log

Each line scan is logged in the output tabulator view. It contains the image name, the measured total distance in pixel and the x and y vector length in both units: pixels and natural units. The log dialog allows to print and log the logged data.

Options

☐ **Plot linescan**

☐ Use [Unit.x] for plot and table output

☐ Draw line permanently

Label: distance in [pix]

Font-size: 8

### Label settings

If you want to label your line scan, activate the "Draw line permanently" option. You might also add a text label to the line scan. Therefore, select the applicable option ("distance in pix", "distance in x with or without unit label"). The text labels are drawn only if the "Draw line permanently" option is selected.

### Label options

Select the pen size, anti-aliasing and color options in the pen group box:

Pen

Size: 2

☐ Antialiasing

Color: [Black color swatch]

The cap style can be modified in the cap style section:

Cap Style

☐ Round

☒ Square

The line ends and arrow styles are set in the arrow / line style group box:

Arrow/Line style

← [Line style] →

Head size: 4

### Analyse object

When routinely having to process measurement data in the lab, it is sometimes very useful to be able to quickly determine the geometric properties of objects in an image. This can be done with dotCube in an easy manner: by drawing a circle around the area where the object is located, the object is identified and usual properties as circumference, area, volume, fractal dimension etc are computed right away.

Go on reading for detailed explanation about:

- [Search options](#)
  - [Threshold](#)
  - [Drift correction](#)

- [Enhanced surface filter](#)
- [Find single or multiple objects](#)
- [Object properties](#)
  - [ID](#)
  - [Colors and font size](#)
  - [Output parameters](#)
  - [Selection options](#)

The screenshot shows two panels from the dotCube software interface. The top panel, titled 'Options', contains a 'Threshold' slider set to 90,00, three checked checkboxes for 'Drift correction between images', 'Enhanced surface filter', and 'Find only the n largest objects', and an 'n =' slider set to 1. The bottom panel, titled 'Object properties', contains an 'Object ID' slider set to 0, a 'Font size' slider set to 4, two buttons labeled 'Output' and 'Colors', and an unchecked checkbox labeled 'Mark object (selection)'.

## The Search options

Although the analyze object function is really powerful, there are only a few and easy to adjust settings.

### Threshold

The "Threshold" value specifies the minimum height difference between the surrounding surface and the object pixels. The surrounding surface height is determined by the pixels you used to encircle the object. A low "Threshold" value will assign only data points with a large height difference to an object. The higher the value the smaller the height limitations are. In the upper limit ("Threshold" = 100%) an height limit between surface and object does not exist. But then, the whole encircled area will be identified as an object.

Although the analyze object function is heavily robust, the surrounding height calculations might fail in strongly distorted images. In these cases, we suggest to activate the "[Enhanced surface filter](#)".

### Drift correction

dotCube supports working with large data bundles containing drifting objects as much as barely anything else. If you plan to analyze a distinct object in several images simultaneously, mark the images, activate the "Drift correction" option and encircle your object of interest just in the first image. For reasonable drifting rates the analyze object function will identify strongly reliably the objects in the entire image stack.

### Enhanced surface filter

Working with distorted images may be challenging in general, but the enhanced surface filter accompanies you to face even these problems.

The object search is now working in a very different manner: The surrounding height level is not one single value anymore. Each object pixel candidate is compared to the closest pixel of its surroundings. The impact of measurement artifacts and noise to the search algorithm is nearly completely eliminated. Though the complexity of this function the algorithm will consume some more computing time.

### Find single or multiple objects

The analyze object tool will recognize as many objects as possible. If you are interested in a limited quantity, activate the "Find only n largest objects" and specify the quantity.

## Object properties

The various output options are neatly arranged in the output group box.

### ID

The analyze object function assigns an unique identification number ("ID") to each object. Define your preferred ID in the object ID panel.

### Colors and font size

The font size of the displayed object ID is defined in the font size panel. Insert any font size you prefer.

The colors are adjustable by clicking on the "Colors" button. In this dialog, you might switch on or off and colorize each computed object property. For detailed explanation see the [color dialog](#) in the object recognition section.

### Output parameters

A great bunch of computable properties is available. Click on the "Output" button to select your favorites. For detailed information see the [output properties](#) dialog in the object recognition section.

### Selection options

dotCube offers to mark any found object for later editing. Select the "Mark object" option if necessary.

### Edit object

The edit object tool helps you to manage evaluated objects. You might modify their graphical representation as well as extract object property values. Because of the basic concept in dotCube: **"Every effect or function will be applied to any selected item"** you have to select the appropriate options in the "On other selected images..." menu when working with multiple images.

Select

- "...do nothing" if the other selected images should be ignored
- "...do the same to any object with the same ID if you want to modify every object with equal ID in each selected image
- "...do the same at the same position" if you want to modify objects in every selected image at the equivalent image position.

Read on for further details:

- [Extract numeric data](#)
  - [List properties](#)
  - [List pixels](#)
- [Rename objects](#)
  - [Change ID of a single object](#)
  - [Unite objects and allocate a new ID](#)
- [Change selection status](#)
  - [Select object pixels](#)
  - [Deselect object pixels](#)
- [Modify graphical representation](#)
  - [Change colors and label size](#)
  - [Show or hide objects](#)
  - [Delete objects](#)
  - [Z order of objects](#)



## Extract numerical data

The edit object tool enables you to extract numeric results from previously found objects. Once an object is found, its coordinates are stored in the [object layer](#) of the corresponding image. As a consequence, any [object property](#) of your interest can be determined by the edit object tool in future analysis processes.

## List properties

The edit object tool provides access to properties and pixels of previously calculated objects. To determine object properties and insert them into a [table](#), select the "List properties" option. The maintenance button on the right opens the object properties dialog which asks you how the data should be arranged and which properties should be listed. If some [object properties](#) were not yet calculated, they are determined from the edit object tool. In this way, you are able to work with the entire object properties set no matter how many properties were originally determined when the objects were found.

## List pixels

You can obtain pixels of previously found objects by the "List pixels" option. Select this option and click on the demanded object. The edit object tool displays a [table](#) containing

- x coordinate in pixel units
- y coordinate in pixel units
- x coordinate in native units
- y coordinate in native units
- z values
- boolean flag if pixel belongs to border
- boolean flag if pixel belongs to [skeleton](#)
- boolean flag if pixel belongs to the largest [skeleton branch](#).

With the help of the [sort functions](#) of the dotCube table section, you are able to extract object pixels with distinct properties like border or skeleton pixels.

## Rename objects

Every object gets automatically an ID. This ID is a unique number within the image where the object is found. The uniqueness is crucial because object data should not be mixed up. The edit object tool provides a dialog which enables you to change the ID of any object. If you choose a already used ID dotCube will automatically rename the other object because of the crucial uniqueness.

## Change ID of a single object

To change an ID of a single object, select the "Change id" option and click onto an object of a selected image. The change ID dialog asks for a new ID.

## Unite objects and allocate a new ID

If you would like to unite multiple objects and allocate a distinct ID, the following process is the way to go:

1. Select the "Select pixels" option of the edit object tool.
2. Click on any objects you want to unite with each other so their pixels are selected.
3. Open the "[Advanced properties dialog](#)" on the "Object layer" page in the [icon bar](#). Select each demanded object (do not check or uncheck but select the entire data cell). Click the "Remove sel. object" button and when finished the "Apply changes" button.
4. Select the "[Transform mask to object](#)" function from the image processing section (Image processing → Transform mask to object).
5. Choose the "Create one object" option and choose the ID manually.

6. Press "Start".

## Change selection status

The edit object tool enables you to select or deselect object pixels.

### Select object pixels

To select pixels of an object, choose the "Select pixels" option and click onto an object.

### Deselect object pixels

To deselect pixels of an object, choose the "Deselect pixels" option and click onto an object.

## Modify graphical representation

The edit object tool provides several possibilities to change the objects' colors, label size, visibility statuses, z order as well as their plain existence. While the "On other selected images..." options box governs the treatment of other selected images, the "Draw options" box gives you the possibility to apply your changes to one or all objects of the current images. Afterwards, other selected images are treated like in the "On other selected images..." options box stated.

### Change colors and label size

The color and label size options might be applied to a single or each object:

- To apply this option to **one object**, select the "Change appearance" option, set the label and color settings and click onto an object.
- To apply this option to **every object** of the current image, click the appropriate "Change all" button (next to label size or color settings).

### Show or hide objects

The show and hide options of objects might be applied to a single or each object:

- To apply this option to **one object**, select the "Show / Hide" option and click onto an object.
- To apply this option to **every object** of the current image, click "Show object layer " or "Hide object layer".

### Delete objects

Select the "Delete" option and click onto an object to delete this one from the image and thereby from the object layer.

### z order of objects

Select the "Bring to front / back" option and click onto an object to set this object in front or behind any other object in the current image.

Left Click  
 Change appearance ▼ 🔧

Shift + Left Click  
 Bring to front ▼ 🔧


On other selected images...

☐ ...do nothing. ☒ ...do the same to any object with the same ID.

☐ ...do the same at the same position.

Draw options

Label size:  
 8 ▲ ▼ Change all

 Colors Change all

Show object layer Hide object layer

## Align by object

The align by object tool enables the user to correct drift in images in respect to previously analyzed objects. After usage of the [analyze object](#) tool or the [object recognition](#) function, the images are placed according to the position of an object occurring in each image. The object has to be labeled by the same [ID](#) in each image. To change object IDs, use the "[Edit object](#)" tool.

The images are stacked drift corrected on each other and the displacement can be filled into a table. To export the drift corrected image sequence, see the [movie chapter](#) in the [export section](#).

Proceed as followed:

1. Select the images you want to be drift corrected
2. Choose the alignment position: [center of area](#) or [center of mass](#)
3. Select the "Write Delta(pos) to table" if applicable
4. Click on an object which occurs in each image labeled with the same ID.
5. The "Align by object" tool processes the drift correction.

**Info**  
 Click on an object and all selected images will be aligned.

Align by ...

☒ Center of area  
☐ Center of mass

☒ Write Delta(pos) to table

## Lattice

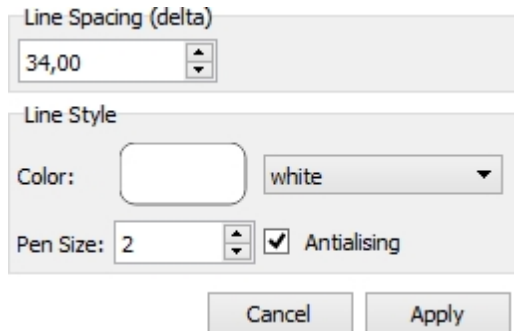
The purpose of the "Lattice" tool is to analyze periodic and crystalline structures. After adjusting a grid to your periodic features, the periodic distance as well as the angle are displayed in the output section.

Proceed as followed:

1. Mark the images you want to analyze.
2. Select your favorite line style: color, pen size and optional anti-aliasing.
3. Click in the image and draw a line. The grid is now displayed.
4. Adjust the line spacing.
5. Click "Apply".
6. The output values (distance and angle) are displayed in the output section.

**Note:** As long as you did not click "Apply", you might still modify each grid setting, even draw a new origin

grid line.



Line Spacing (delta)  
34,00

Line Style

Color:

Pen Size: 2 ☒ Antialiasing

Cancel Apply

## Draw

The draw repository contains the major tools needed to add drawn elements to your image.

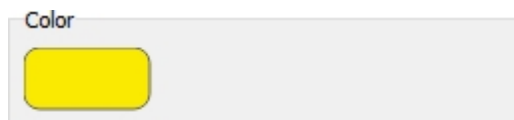
**Note:** In dotCube, each effect or function is applied to any selected item. E.g: If you plan to add a sketch to a bunch of images, just select them and process your drawing on one of these images. Your sketch will be added to any of the selected ones.

Read on for detailed explanation:

- [Pencil](#)
- [Paintbrush](#)
- [Line, Arrow](#)
- [Bucket fill](#)
- [Color picker](#)
- [Eraser](#)

## Pencil

Use the pencil to draw lines with a line width of one pixel. Just select an image, choose your favorite color and click and move the mouse within your selected image.



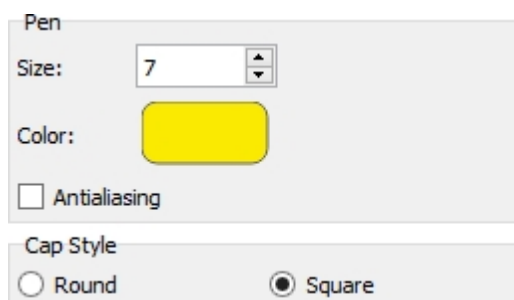
Color

## Paintbrush

Use the pencil to draw lines with a line width thicker than one pixel.

Proceed as followed:

1. Select images.
2. Choose pen size, color and optional anti-aliasing.
3. Specify the cap style which basically defines the shape at the end of your brushed line: a round shape or just rectangular
4. Click into an image, move the mouse and brush.



Pen

Size: 7

Color:

☐ Antialiasing

Cap Style

☐ Round ☒ Square

## Line, Arrow

Use the "Line, arrow" tool to draw lines with arrow endings and / or customized line styles.

Proceed as followed:

1. Select images.
2. Choose pen size, color and optional anti-aliasing.
3. Specify the cap style which basically defines the shape at the end of your brushed line: a round shape or just rectangular
4. Define the line style and its both endings and the arrow head length if applicable.
5. Click into an image, move the mouse and brush.

Pen

Size: 3

Color:

☒ Antialiasing

Cap Style

☐ Round ☒ Square

Arrow/Line Style

← --- →

Arrowhead Length

10

## Bucket fill

The bucket fill drawing tool fills a contiguous region of similar color or similar z values with a specified color. Nevertheless, bucket fill applies the color only to the picture layer like the other drawing tools and does not change z values.

See detailed explanation:

- [Define color](#)
- [Adjust tolerance and select reference](#)
- [Restrict function to selected pixels](#)

## Define color

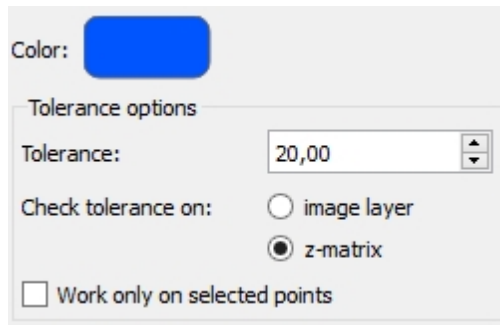
Click on the color button at the top of the dialog to work with the color dialog window.

## Adjust tolerance value and select reference

The bucket fill tool starts at a pixel which is defined by a mouse click. Any connected pixels of similar color or z values are colorized which are within the tolerance range. Pixels within the tolerance range are determined either in respect to colors in the picture layer or in respect to the z layer. For detailed explanation of the tolerance options, see the related magic wand tool. If you have questions about the distinct image layers, see the section "Working with items and their layers" in the "Collection" chapter.

## Restrict function to selected pixels

The bucket fill function might be limited to previously selected pixels. To start with this option, you have to click onto a selected pixel.



Color:  

Tolerance options

Tolerance:

Check tolerance on: ☐ image layer ☒ z-matrix

☐ Work only on selected points

## Text

The text function adds descriptions to selected images. You might exploit the default options to style your messages or write html-style tags on your own. With the dotCube text function you gain access to the entire html world to design really customized descriptions.

Read on for detailed explanations how to

- [Change font and color](#)
- [Write text](#)
- [Add special characters](#)
- [Place text into images](#)

## Change font and color

The font, their style and color are modified in the font dialog box. There, you select

- font
- size
- color
- style

## Write text

The lower dialog box contains the text messages which are added to selected images. Beside plain text you might insert special characters from the combo boxes above, write your own html code and place raise text parts. The "Clear" button delete the entire text dialog box.

## Add special characters

The most common mathematical symbols and characters are predefined and placed in one of the special characters dialog boxes. You might use html code to write even more complicated styles and descriptions.

## Place text into images

The text is inserted by clicking into a selected image. Since more than one image could be selected, the text is inserted into any selected image at the relative mouse click position.

**Font**

Name:

Size:  Color:

☐ Underline ☐ Italic

☐ Bold ☐ Strikethrough

**Text**

√ ▾ α ▾ Γ ▾

Hint: You can also use html-tags.

## Color picker

To select pen and fill colors easily, use the "Color picker".

**Note:** The "Color picker" tool is one of the rare dotCube functions, which only proceed within one single image.

Proceed as followed:

1. Select a single image.
2. Define if you want to pick a pen or a fill color.
3. Click into an image on your favorite color.

**Color**

Pen: ☒

Fill: ☐

## Eraser

The eraser tool deletes pixels within the picture layer of images. The dimensions can be modified by the radius setting. For erasing something, select one or more images, click onto one, hold the left mouse button and move the mouse. Every pixel around the mouse position and inside the specified radius will be deleted from the image layer.

**Radius**

## Shapes

The "Shapes" repository contains the most common geometric shapes.

**Note:** In dotCube, each effect or function is applied to any selected item. E.g: If you plan to add a sketch to a bunch of images, just select them and process your drawing on one of these images. Your sketch will be added to any of the selected ones.

Read on for detailed explanation:

- [Rectangle](#)
- [Ellipse](#)
- [Round rectangle](#)
- [Freehand](#)
- [Freehand \(lines\)](#)

## Rectangle

Use the rectangle tool to draw rectangular shapes with different line width, border styles and colors.

Proceed as followed:

1. Select images.
2. Choose border line size, color and optional anti-aliasing.
3. Specify the border line style.
4. Define the brush style inside your figure:
  - solid
  - horizontal
  - vertical
  - cross
  - diagonal left, right or cross
  - no filling
5. Click into an image and drag the mouse to span your geometric figure.

Border

Size: 2

Color:

☒ Antialiasing

Border Style

-----

Brush Style

solid

Color:

## Ellipse

Use the "Ellipse" tool to draw elliptical shapes with different line width, border styles and colors.


Proceed as followed:

1. Select images.
2. Choose border line size, color and optional anti-aliasing.
3. Specify the border line style.
4. Define the brush style inside your figure:
  - solid
  - horizontal
  - vertical
  - cross
  - diagonal left, right or cross
  - no filling
5. Click into an image and drag the mouse to span your geometric figure.




**Border**

Size:

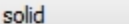
Color: 


☒ Antialiasing

**Border Style**



**Brush Style**



Color: 

## Round rectangle

Use the "Round rectangle" tool to draw rectangular shapes with blunt edges and different line width, border styles and colors.

Proceed as followed:

1. Select images.
2. Choose border line size, color and optional anti-aliasing.
3. Specify the border line style.
4. Define the brush style inside your figure:
  - ☐ solid
  - ☐ horizontal
  - ☐ vertical
  - ☐ cross
  - ☐ diagonal left, right or cross
  - ☐ no filling
5. Click into an image and drag the mouse to span your geometric figure.

**Border**

Size:

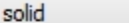
Color: 

☒ Antialiasing

**Border Style**



**Brush Style**



Color: 

## Freehand

Use the "Freehand" tool to draw complicated shapes with different line width, border styles and colors.

Proceed as followed:

1. Select images.
2. Choose border line size, color and optional anti-aliasing.
3. Specify the border line style.
4. Define the brush style inside your figure:

- solid
  - horizontal
  - vertical
  - cross
  - diagonal left, right or cross
  - no filling
5. Click into an image and drag the mouse to span your geometric figure.

Border

Size:

Color:

☒ Antialiasing

Border Style

Brush Style

Color:

### Freehand (lines)


Use the "Freehand (lines)" tool to draw complicated shapes with straight border lines and different line width, border styles and colors.

Proceed as followed:

1. Select images.
2. Choose border line size, color and optional anti-aliasing.
3. Specify the border line style.
4. Define the brush style inside your figure:
  - solid
  - horizontal
  - vertical
  - cross
  - diagonal left, right or cross
  - no filling
5. Click into an image and drag the mouse to span the first line.
6. Click again to define the next edge pixel.
7. Close the figure by clicking within an one pixel range onto a previously drawn line.


Border

Size:


Color: 


☒ Antialiasing

Border Style



Brush Style



Color: 

## Image processing

---

The image processing section forms the core of the dotCube software package. It provides powerful image tools for processing and analyzing images:

- [Plane correction](#)
- [Drift correction](#)
- [Object recognition](#)
- [Voronoi construction](#)
- [Fourier transformation](#)
- [Derivative calculation](#)
- [Z-matrix manipulation](#)

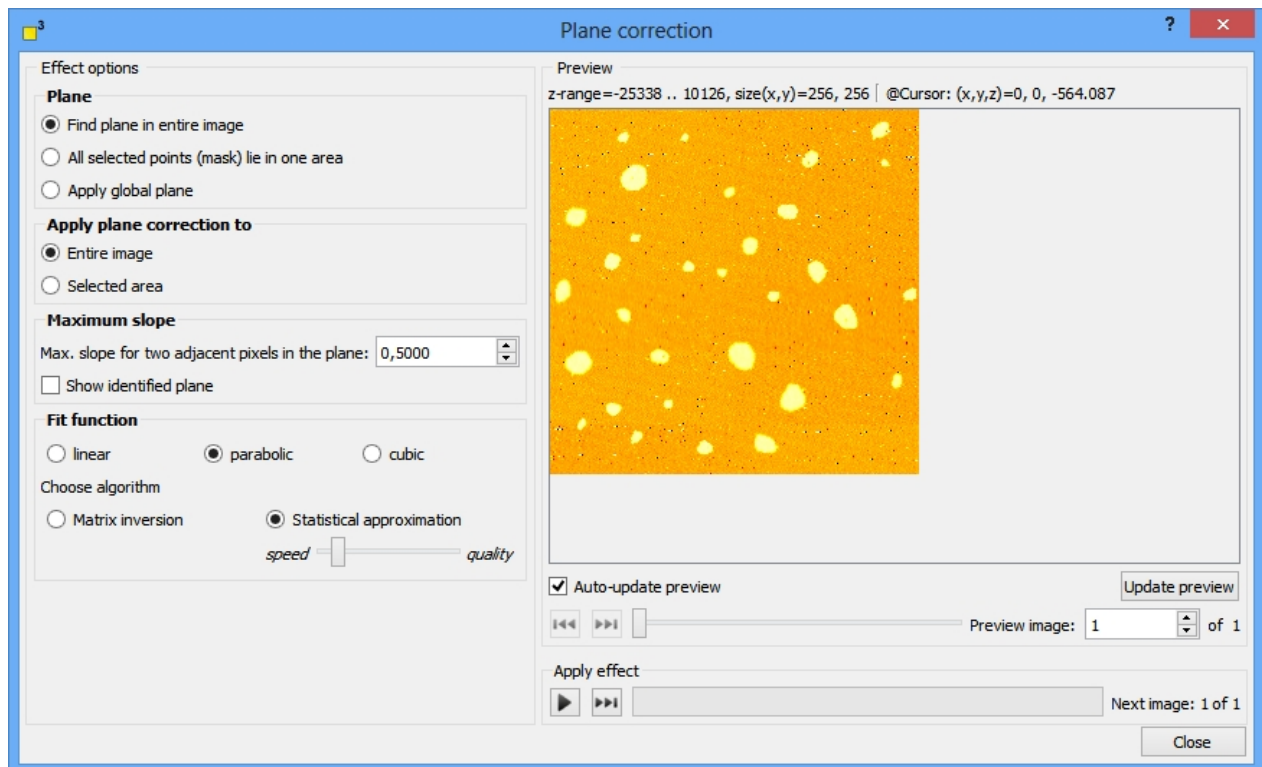
In the following chapters we explain every function in detail.

### Plane correction

Many microscopes record images due to their setup in a tilted manner. Before starting the analysis process the correction of the tilt is crucial. Otherwise large errors will occur in course of the analysis process. The area calculation for instance would accidentally assign data pixels to objects where simply the surrounding structures exhibit apparently similar heights as the objects. Therefore, dotCube supports the scientists with extensive options to correct tilted images precisely and fast.

Read on for getting to know in detail about:

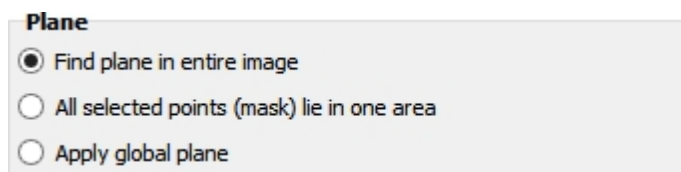
- [How to detect the plane](#)
- [Where to apply the correction](#)
- [How to determine the detection level](#)
- [Two complementary correction algorithms](#)
- [Shortcut keys](#)



## How to detect your plane

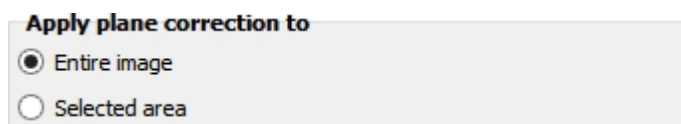
DotCube is able to process the plane detection in three different ways:

- The first option **"Find plane in entire image"** will start an automatic plane search.
- For strongly distorted and noisy images, the second option may function more reliably. Therefore, mark manually one or more flat regions and choose the **"All selected points lie in one area"** option. Correction functions are calculated and applied to your image according to the marked data points. A minimum of 16 data points has to be marked.
- If the whole image features mainly one flat base level, the option **"Apply global plane"** will be the best choice.



## Where to apply the plane correction

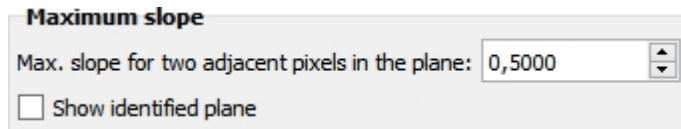
The plane correction may be applied to a previous marked area or to the whole image. Just select the respective option.



## Determine the detection level

DotCube detects flat regions in scan data by calculating locally the second derivative. Data points which exceed the value specified by **"Maximum slope factor"** are allocated to a flat region - a plane. Increase or

decrease this value to assign more or less data points to the plane.



**Maximum slope**

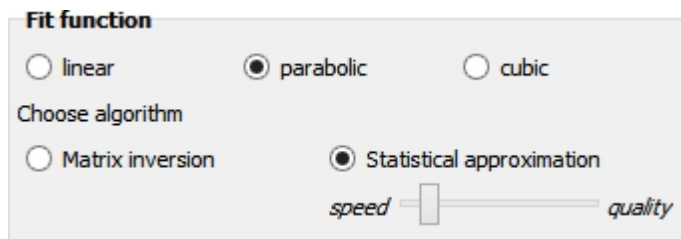
Max. slope for two adjacent pixels in the plane:

☐ Show identified plane

For monitoring the detected plane, select the **"Show identified plane"** option.

## Select the correction algorithm

After detecting a planar region, a three dimensional correction function is applied to the image data in order to remove the tilt. Select the **polynomial order** (linear, parabolic or cubic) of the tilt distortion to gain the best results.



**Fit function**

☐ linear      ☒ parabolic      ☐ cubic

Choose algorithm

☐ Matrix inversion      ☒ Statistical approximation

speed  quality

The correction function can be calculated by two algorithms:

- **Matrix inversion:** This algorithm is the fastest, but works only for functions of linear or parabolic order. The results of linear correction functions calculated by matrix inversion are comparable with the statistical approach of the second algorithm. But the parabolic correction results may be more accurate calculated by the statistical approximation algorithm.
- **Statistical approximation:** This algorithm consumes more computing time, but gains more precise results for higher polynomial orders. Select the proportion between speed and quality which suits your data best with the slider.

## Shortcut keys

The execution of the function may be started by pressing two different shortcut keys:

- **Return:** The function will be applied to all selected images.
- **Shift+Return:** The function will be applied to the next selected image only.

For more shortcut keys see our [detailed list](#).

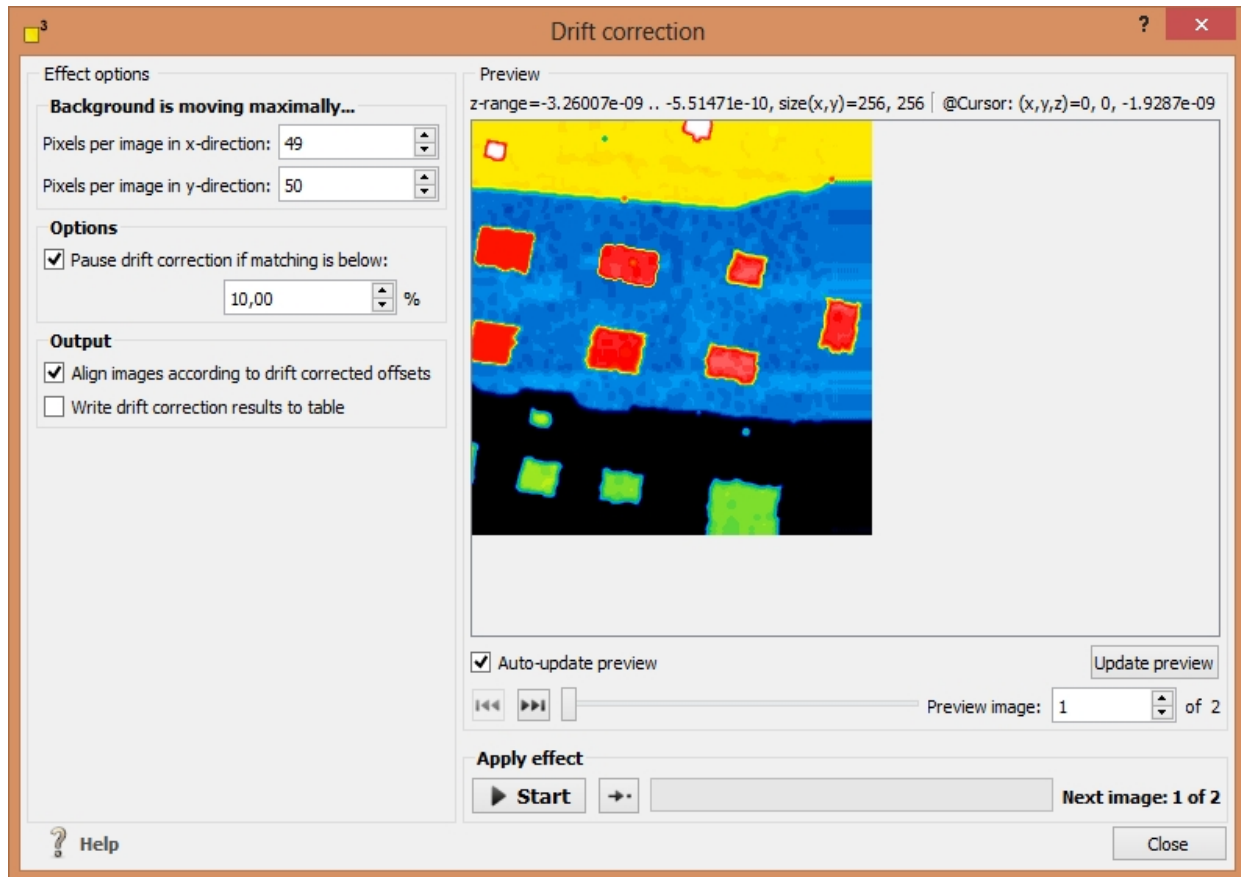
## Drift correction

For gaining outstanding scientific results it is obligatory to shift the borders of feasible measurements to extreme conditions. Despite great results the outcome often contains side effects like image drift potentially caused by an unstable temperature or unstable objects. That is the point where dotCube cuts in helping you to process your data leading to impressive stable image sequences or movies. Two kinds of drift corrections are available: The general "Drift correction" in the image processing menu bar and the ["Align by object"](#) tool in the [scientific tool bar](#). Do not forget to emphasis interesting features by using the [drawing features](#) before you [cut](#) your image sequence and [build a movie file](#) to impress your colleagues.

Read on for getting to know in detail about:

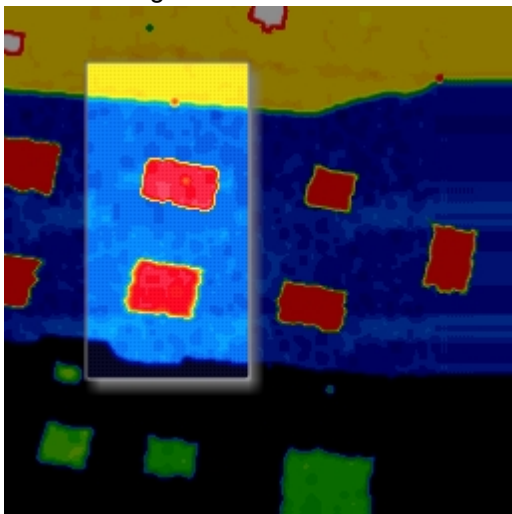
- [Define a prominent image part as a reference](#)
- [Select images](#)
- [Specify drift limits](#)
- [Feedback options](#)
- [Output options](#)

- [Shortcut keys](#)



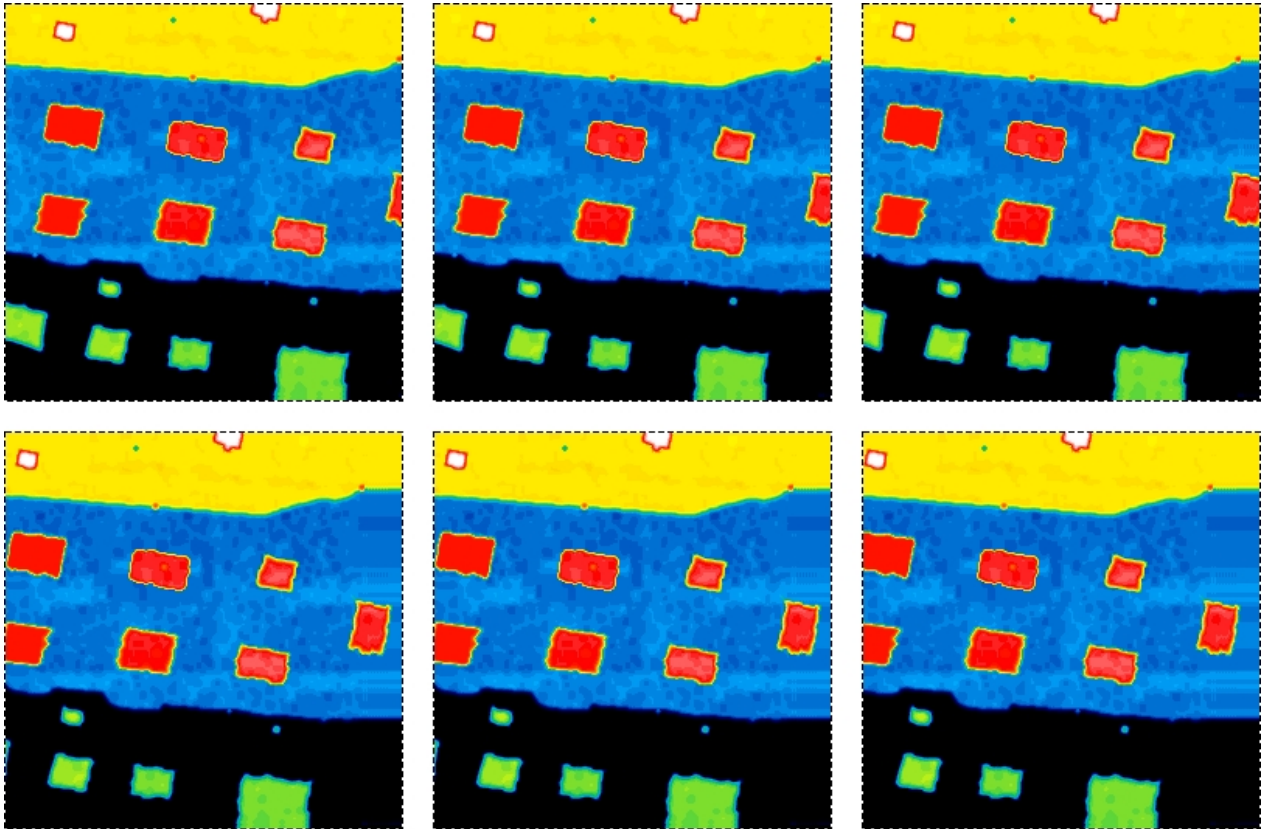
## Define a prominent image part as a reference

For correcting drift in selected images, you first have to [select](#) a prominent part in the first image. This region has to occur in all images you want to apply the drift correction to. The drift will be corrected in respect to the best fit of the selected reference region. The best choice are unique image features with sudden changes in z direction.



## Select images

After defining a reference region, select the images which should be drift corrected. Therefore, change to ["Default cursor"](#), press the shift key and click onto any favored image.



## Specify drift limits

Estimate the maximum **drift components** in x and y direction. Larger drift limits will increase the time consumption of the drift correction algorithm. Hence, select applicable values.

## Feedback options

A low contrast as well as a high noise level may infect seldomly the identification rate of the reference region in an image. An improper **matching of reference regions** may result in a false drift correction. Therefore, dotCube provides an option to pause the effect below a certain matching value. This enables you to abort the process and adjust the drift settings or correct your sequence in a different way.

## Output options

Two output options are available:

- **align** images according to corrected offsets
- insert the calculated **offsets** into a new [table](#).

1	2	3	4	5	6	7	8	9	10	11	12	13
Image number	Image name	Position.x [px]	Position.y [px]	Position.x [Unit.x]	Position.y [Unit.y]	Drift.x [px]	Drift.y [px]	Drift.x [Unit.x]	Drift.y [Unit.y]	Unit.x	Unit.y	Matching [%]
1	2010-03-25 16.10.31	0	0	0	0	0	0	0	0	Angstrom	Angstrom	100
2	2010-03-25 16.10.59	0	-3	0	-11.7188	0	-3	0	-11.7188	Angstrom	Angstrom	45.3431
3	2010-03-25 16.11.27	0	-6	0	-23.4375	0	-6	0	-23.4375	Angstrom	Angstrom	48.3036
4	2010-03-25 16.11.56	1	-10	3.90625	-39.0625	1	-10	3.90625	-39.0625	Angstrom	Angstrom	46.6037
5	2010-03-25 16.12.24	1	-13	3.90625	-50.7812	1	-13	3.90625	-50.7812	Angstrom	Angstrom	40.4787
6	2010-03-25 16.12.52	1	-17	3.90625	-66.4062	1	-17	3.90625	-66.4062	Angstrom	Angstrom	45.3972
7	2010-03-25 16.13.20	1	-22	3.90625	-85.9375	1	-22	3.90625	-85.9375	Angstrom	Angstrom	46.8032
8	2010-03-25 16.13.48	1	-27	3.90625	-105.469	1	-27	3.90625	-105.469	Angstrom	Angstrom	66.1502
9	2010-03-25 16.14.16	1	-33	3.90625	-128.906	1	-33	3.90625	-128.906	Angstrom	Angstrom	56.2746
10	2010-03-25 16.14.44	0	-39	0	-152.344	0	-39	0	-152.344	Angstrom	Angstrom	35.4399
11	2010-03-25 16.15.12	0	-42	0	-164.062	0	-42	0	-164.062	Angstrom	Angstrom	30.5444
12	2010-03-25 16.15.40	0	-48	0	-187.5	0	-48	0	-187.5	Angstrom	Angstrom	52.3349
13	2010-03-25 16.16.08	0	-54	0	-210.938	0	-54	0	-210.938	Angstrom	Angstrom	61.7289
14	2010-03-25 16.16.36	0	-59	0	-230.469	0	-59	0	-230.469	Angstrom	Angstrom	45.0227
15	2010-03-25 16.17.04	3	-59	7.8125	-230.469	2	-59	7.8125	-230.469	Angstrom	Angstrom	19.1474
16	2010-03-25 16.17.32	4	-60	15.625	-234.975	4	-60	15.625	-234.975	Angstrom	Angstrom	63.262
17	2010-03-25 16.18.01	8	-60	23.4375	-234.975	8	-60	23.4375	-234.975	Angstrom	Angstrom	61.0853
18	2010-03-25 16.18.29	8	-59	21.25	-220.469	8	-59	21.25	-220.469	Angstrom	Angstrom	36.9402
19	2010-03-25 16.18.57	11	-59	42.0625	-230.469	11	-59	42.0625	-230.469	Angstrom	Angstrom	54.3815
20	2010-03-25 16.19.25	12	0	46.075	-244.125	12	0	46.075	-244.125	Angstrom	Angstrom	52.3473

## Shortcut keys

The execution of the function may be started by pressing two different shortcut keys:

- **Return:** The function will be applied to all selected images.
- **Shift+Return:** The function will be applied to the next selected image only.

For more shortcut keys see our [detailed list](#).

## Object recognition

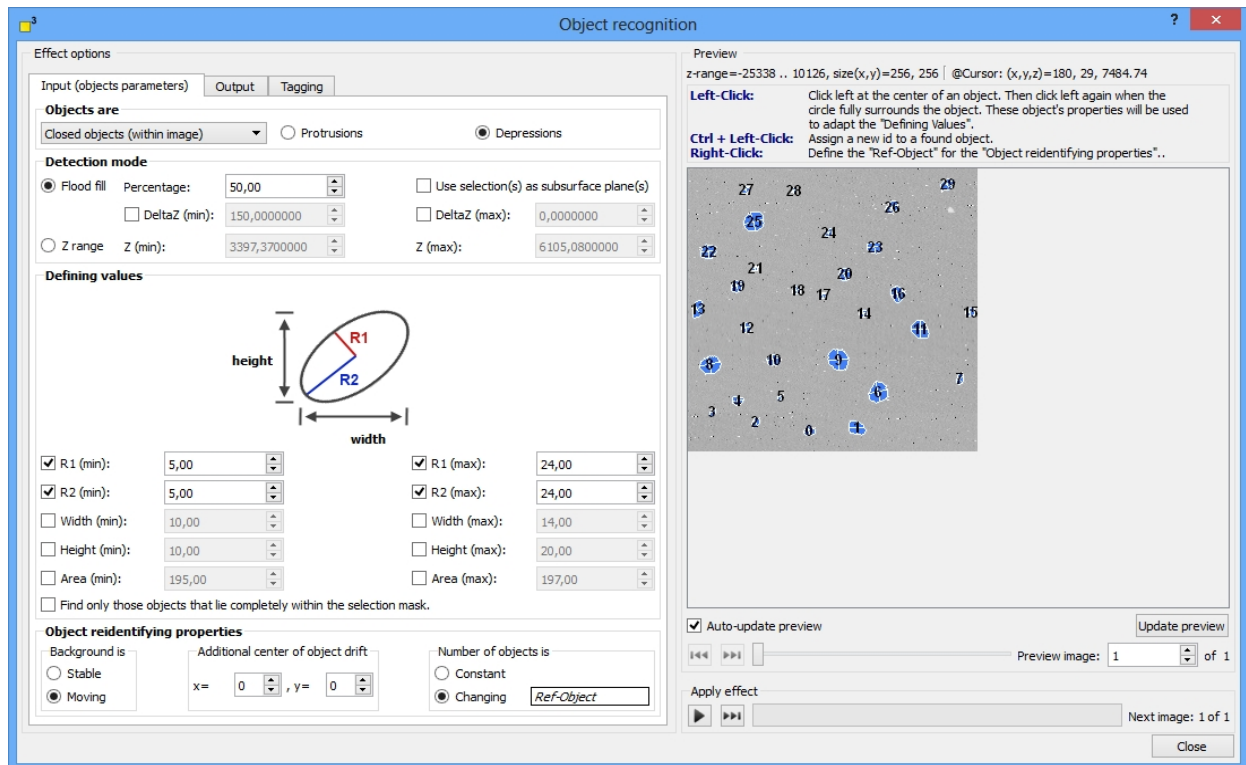
The possibility of identifying, analyzing and tracking structures and objects is probably the central feature of the dotCube project. This is done via a rich function library which will enable you to analyze structures in great detail and track data in a dependable and time-efficient manner. Once a structure has been identified, the structure itself and the changes that occurred to it can be tracked across multiple images.

Read on for getting to know in detail about:

- [Input parameters](#)
  - [Object properties](#)
  - [Detection mode](#)
- [Output parameters](#)
  - [Computing results - the output selection dialog](#)
    - [One dimensional results](#)
      - [Width](#)
      - [Height](#)
      - [Maximum inner radius](#)
      - [Minimum outer radius](#)
      - [Circumference](#)
      - [Main axes](#)
      - [Largest extend](#)
      - [Skeleton](#)
      - [Center of area](#)
      - [Center of mass](#)
      - [Heywood diameter](#)
    - [Two dimensional results](#)
    - [Three dimensional results](#)
      - [Area](#)
      - [Bounding box](#)
    - [Geometry](#)
      - [Aspect ratio](#)
      - [Compactness](#)



- [Fractal dimension](#)
  - [Elongation](#)
  - [Orientation](#)
- [Colors and labeling](#)
- [Object filter](#)
- [Tracking](#)
  - [Tracking parameters](#)
  - [Manual tagging](#)
- [Shortcut keys](#)



## Input parameters

The object recognition dialog is designed to speed up the analysis process. Therefore, the most common used control elements are placed on the first **"Input parameters"** page in the tabulator view. The **input parameters** define structural requirements, which help to identify user-demanded valid objects.

For starting the analysis process, define

- [Object properties](#) and
- [The detection mode](#).

Input (objects parameters)
Output
Tagging

**Objects are**  
Closed objects (within image)
Protrusions
Depressions

**Detection mode**  
☒ Flood fill
Percentage: 50,00
☐ Use selection(s) as subsurface plane(s)  
☐ DeltaZ (min): 150,0000000
☐ DeltaZ (max): 0,0000000  
☐ Z range
Z (min): 3397,3700000
Z (max): 6105,0800000

**Defining values**  

height

width

☒ R1 (min): 5,00
☒ R1 (max): 24,00  
☒ R2 (min): 5,00
☒ R2 (max): 24,00  
☐ Width (min): 10,00
☐ Width (max): 14,00  
☐ Height (min): 10,00
☐ Height (max): 20,00  
☐ Area (min): 195,00
☐ Area (max): 197,00  
☐ Find only those objects that lie completely within the selection mask.

**Object reidentifying properties**  
Background is  
☐ Stable  
☒ Moving  
Additional center of object drift  
x = 0 , y = 0  
Number of objects is  
☐ Constant  
☒ Changing
Ref-Object

## Object properties

The fundamental properties are defined in the **"Objects are..."** group box.

**Objects are**  
Closed objects (within image)
Protrusions
Depressions

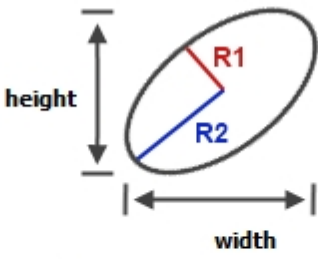
Select the physical border appearance of your favorite objects:

Property	Description
<i>Closed objects</i>	The border of the objects proceeds continuously and is not broken by the image boundaries (e.g. an elliptical shape).
<i>Open objects</i>	The object border is broken up (e.g. an half circular object bordering at the image boundaries).
<i>Open and closed objects</i>	All objects are valid regardless of their border progression.

Specify if your wanted objects are valley-like depressions or mountain-like protrusions by selecting the applicable option **"Depression"** or **"Protrusion"**.

The more precise geometric properties are defined in the **"Defining values"** group box.

**Defining values**



<input checked="" type="checkbox"/> R1 (min):	<input type="text" value="5,00"/>	<input checked="" type="checkbox"/> R1 (max):	<input type="text" value="24,00"/>
<input checked="" type="checkbox"/> R2 (min):	<input type="text" value="5,00"/>	<input checked="" type="checkbox"/> R2 (max):	<input type="text" value="24,00"/>
<input type="checkbox"/> Width (min):	<input type="text" value="10,00"/>	<input type="checkbox"/> Width (max):	<input type="text" value="14,00"/>
<input type="checkbox"/> Height (min):	<input type="text" value="10,00"/>	<input type="checkbox"/> Height (max):	<input type="text" value="20,00"/>
<input type="checkbox"/> Area (min):	<input type="text" value="195,00"/>	<input type="checkbox"/> Area (max):	<input type="text" value="197,00"/>

☐ Find only those objects that lie completely within the selection mask.

Select any properties which define your favored objects best and specify their values. If you are looking for regular shaped structures, use the **radius** options. For irregular or dendritic shapes, **width and height** are a better choice. The smaller the minimum values are, the more computing time will be used by the [search algorithms](#). But the time consumption is crucial only by selected **"flood fill mode"**. The **"Z range mode"** algorithm is much faster.

If the selected geometric properties are not sufficient, an error message will be displayed.

If you need **assistance for defining the geometric input values**, click on an object of your interest and move the mouse to its border and further onto the surrounding area. The dotCube assistant spans a circle around the clicked position. If the object is fully encircled, click again and the dotCube assistant will suggest a reasonable geometric parameter set.

## Detection mode

Depending on the kind of your data, two complementary algorithms are available:

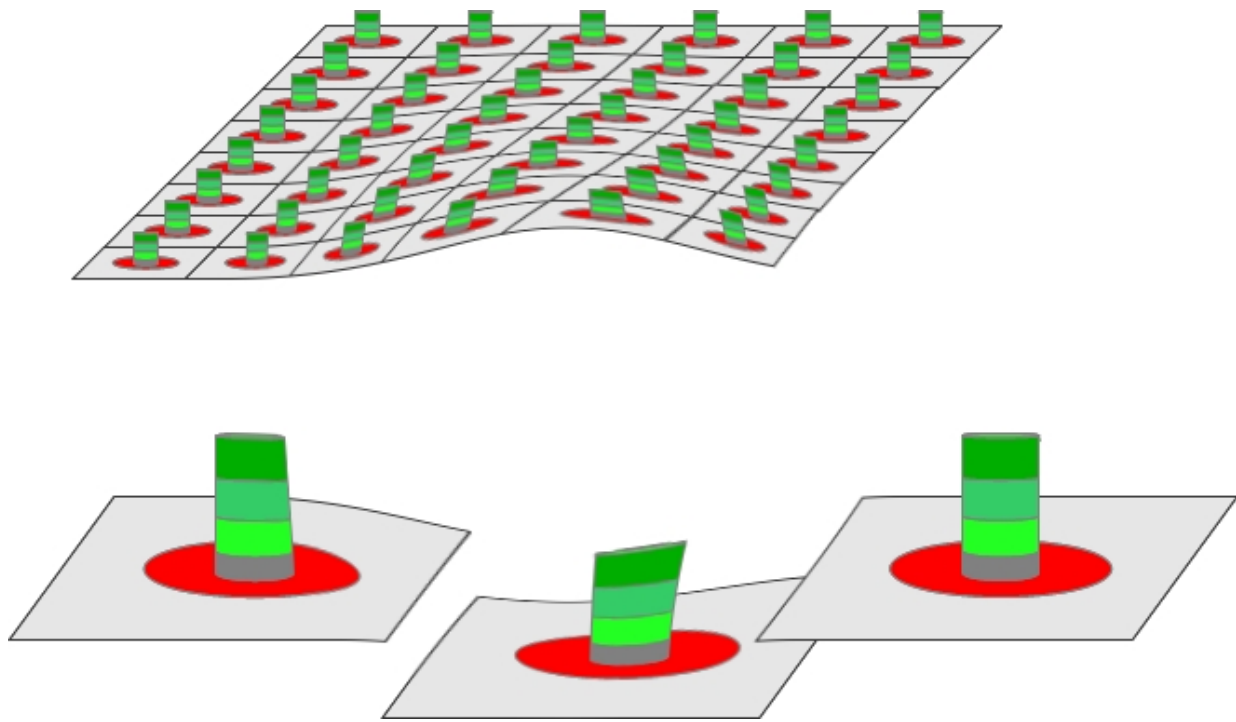
- [Flood fill mode](#) and
- [Z range mode](#).

**Detection mode**

<input checked="" type="radio"/> Flood fill	Percentage:	<input type="text" value="50,00"/>	<input type="checkbox"/> Use selection(s) as subsurface plane(s)
	<input type="checkbox"/> DeltaZ (min):	<input type="text" value="150,0000000"/>	<input type="checkbox"/> DeltaZ (max):
		<input type="text" value="0,0000000"/>	
<input type="radio"/> Z range	Z (min):	<input type="text" value="3397,3700000"/>	Z (max):
		<input type="text" value="6105,0800000"/>	

## Flood fill mode

The flood fill algorithm demands more computing time, but delivers accurate and reliable results even with noisy and slightly distorted image data. Objects are identified by their height differences to their local environment. Thus, the results are highly precise.



The image above shows a schematic drawing with green objects on a gray surface. The flood fill algorithm compares every possible object candidate with its local surrounding height level marked in red. Hence, the green objects are found independently from the curvature of the surface.

The fill **"Percentage"** value specifies the minimum height difference between the surrounding surface and the object pixels. A low **"Percentage"** value will assign only data points with a large height difference to an object (the greenest parts of the sketched objects). The higher the value the smaller the height limitations are. In the upper limit (**"Percentage"** = 100%) an height limit between surface and object does not exist. But then, no objects would be identified, because the [geometric defining restrictions](#) will be exceeded and therefore violated.

Although the flood fill algorithm is heavily robust, the surrounding height calculations might fail in strongly distorted images. In these cases, you may mark manually several surface regions as **reference heights**. The reference height which is closest to each object height will be used.

In addition to the **"Percentage"** value, there is the possibility to add distinct constant height limits which are dispensable for some special analysis processes. If all of the conditions above are fulfilled, but the height difference between object pixel and subsurface is less than the **"Delta z(min)"** value and the **"Delta z(min)"** optional condition is activated, the object will be discarded. If the **"Delta z(max)"** option is selected, any object which exceeds the height difference between itself and the surface named in **"Delta z(max)"** will be discarded.

Let's have a look at an example: We would like to analyze an image, but want to exclude any object, which is less than 10nm higher than its surroundings. Therefore, we would select the **"Delta z(min)"** option and set its value to "10" if nanometers are the natural unit of your image.

## Z range mode

The **"Z range mode"** works much faster than the flood fill mode, but uses only one height range for each object. Any object featuring an height within the specified **"Z (min)"** and **"Z (max)"** range is a valid object and will be found dependent on the [defining geometric properties](#). While this tool is very helpful for searching objects within a absolute distinct height level, a tilted or curved image might causes misleading object results in the **"Z range mode"**. In unfavorable cases, the results might be incomplete objects or artifacts.

## Output parameters

The output parameters section offers to you a rich selection of feasible properties which can be calculated

and displayed in the table section, written into each image header or drawn on the [picture layer](#). Furthermore, the draw settings and the selected objects in the object filter and the filter presets can be changed.

Input (objects parameters)OutputTagging

Selection and table manager

OutputColors

Label size: 12

☐ Set selected (marked) area to found objects

Object filter

ID	Coordinates	Select
0	(167,48)	<input checked="" type="checkbox"/>
1	(176,88)	<input checked="" type="checkbox"/>
2	(15,90)	<input checked="" type="checkbox"/>
3	(86,108)	<input checked="" type="checkbox"/>
4	(26,155)	<input checked="" type="checkbox"/>
5	(89,156)	<input checked="" type="checkbox"/>
6	(83,192)	<input checked="" type="checkbox"/>
7	(198,203)	<input checked="" type="checkbox"/>
8	(243,231)	<input checked="" type="checkbox"/>

Update

Select all

Deselect all

Selection policy:

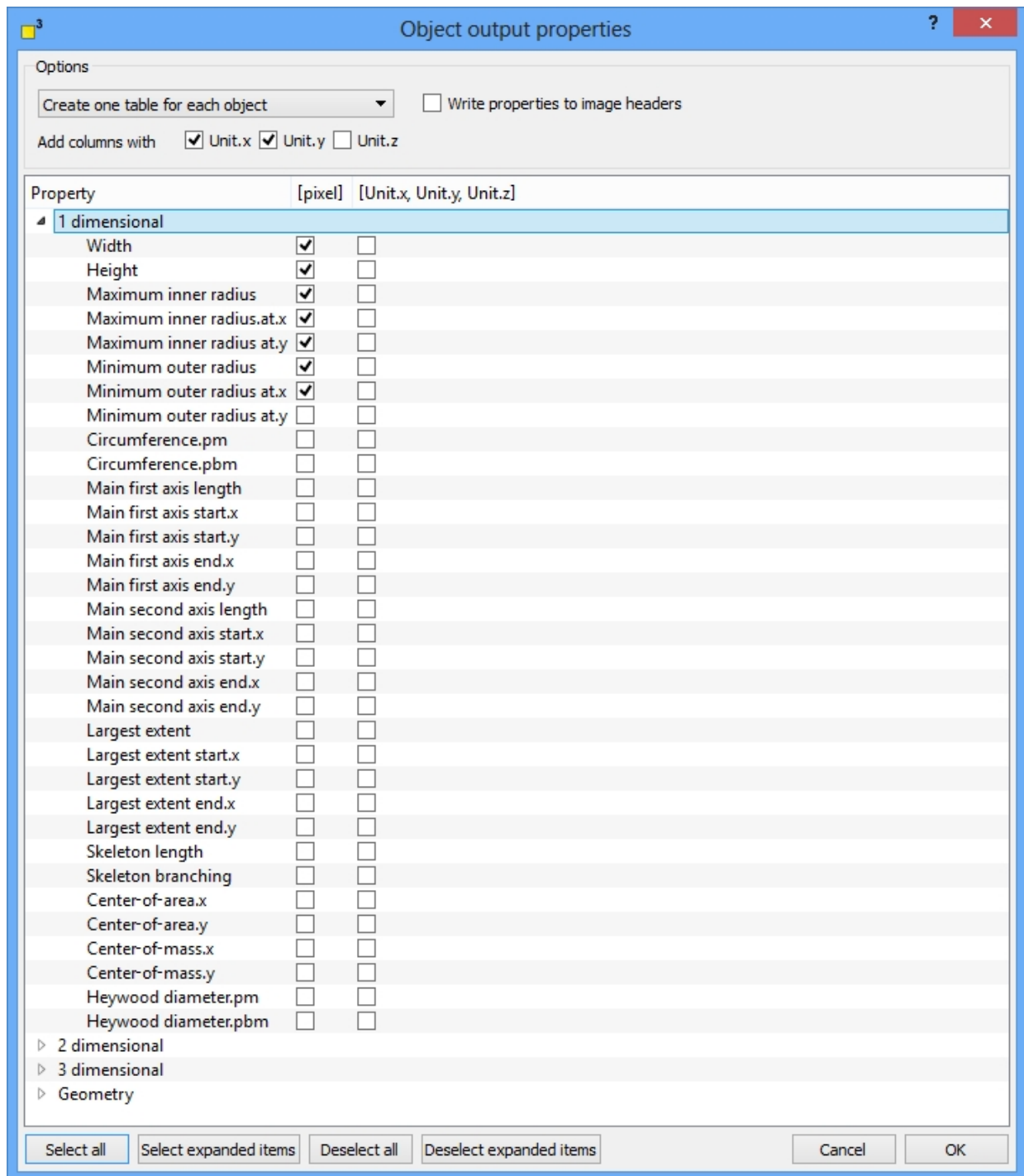
Newly found object are by default

☒ Selected ☐ Unselected

### Computing results - the output selection dialog

The object output properties dialog provides the numerical output options of the object recognition function. Select

- how you would like to display the results: in one or more [tables](#) and/or in the [image headers](#)
- which [properties](#) should be analyzed or drawn and colorize them
- the evaluating objects in the **object filter** and change filter presets
- if the objects should be **marked**.



## Table output

There are four table output options available:

Option	Description
<i>Create one table for each object</i>	For any object in any selected image, a new table is created and filled. E.g.: If one or several images contain an object with the id "3", one new table will be created and filled with object properties of object 3.
<i>Create one table for each image</i>	For any image, a new table is created and the properties of any object in one single image are filled in. E.g.: If you analyze five images, five new tables will be created and they will be filled with properties of any object which was found in each currently analyzed image.

Create one table for all	Only one new table is created and all object properties are filled in.
Add results to current table if appropriate	This option adds every future analysis to the current table if the numbers and titles of table columns fit.
No table output	No tabular output is displayed.

If you decide to display the object properties in **natural units**, you might supplementary add one, two or three columns with the natural units of the x, y and z dimensions. Therefore, select the appropriate "unit" check boxes.

### Header output

All computed object properties might be added to the **image header** for further analysis. Select the "Write properties to image headers" option to do so. The "[Edit object](#)" tool, a member of the [scientific tool bar](#), enables you at any time to list all object properties from the image headers or the **object layer** into tables.

### Property selection

DotCube provides an extensive selection of object properties which can be calculated. They are sorted by [one dimensional](#), [two dimensional](#), [three dimensional](#) and [geometric](#) headlines. Select your favorite properties and if you want them to be displayed in natural units or in pixels. Use the "**Select all**", "**Select expanded items**" as well as "**Deselect all**" and "**Deselect expanded items**" buttons to speed up the selection process.

Read on for detailed explanation of every computable property.

### One dimensional results

#### Width

Returns the expansion in x direction.

#### Height

Returns the expansion in y direction.

#### Maximum inner radius

Calculates the radius of the in-circle.

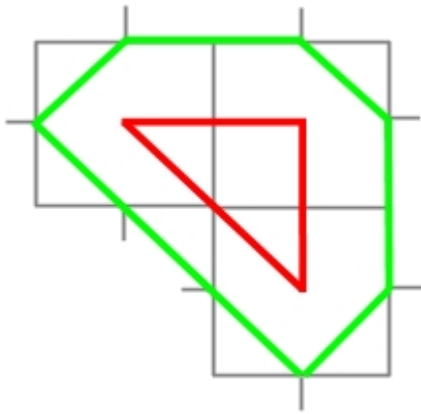
#### Minimum outer radius

Calculates the radius of the perimeter.

### Circumference

Numerical sciences provide a large variety of methods for calculating circumferences of discrete data. DotCube offers two complimentary methods called "pm" and "pbm" outlined in the scheme below. The object pixels are gray colored. The "pm" result is displayed in red color, the "pbm" result in green color:

- Connect **pixel middles** ("pm"): This method provides excellent results for diagonal border elements, but underestimates object border length with a thickness of one single pixel.
- Connect **pixel border middles** ("pbm"): The results for very thin objects are excellent, but diagonal border elements are slightly overestimated.



### Main axes

The main axes section determines the two main directions of the area moment of inertia. DotCube provides their crossing points with the object borders and each axis length.

### Largest extend

Returns the maximum distance of any object pixel.

### Skeleton

The skeleton of an object is determined by the algorithm of T.Y. Zhang and C.Y. Suen described in their publication "A fast parallel algorithm for thinning digital patterns" and published in "Communication of the ACM" (volume 27 number 3). Thereby, the object expansion is shrunk until it exhibits single lines which are called branches. During this process, the deletion of branch endings is nearly but not completely suppressed preserving the origin object length.

The property "Skeleton length" designates the most extensive length of the skeleton. "Skeleton branching" labels the number of branch endings.

E.g.: If you analyze the shape of a worm like structure, the skeleton length names the length of the worm and the skeleton branching will give the value "2" because the worm features two endings.

### Center of area

Denotes the centroid of the object area.

### Center of mass

Labels the x- and y coordinates of the centroid of the object volume.

### Heywood diameter

Designates the equivalent diameter to a circular area. Two different heywood diameters can be calculated ("pm" and "pbm") because there are two different methods to calculate area values depending on its borders (see also [circumference](#) calculation).

$$\text{heywood diameter} = \sqrt{\frac{4}{\pi} \cdot \text{Area}}$$

### Two dimensional results

#### Area



The area denotes the number of pixels which are occupied by an object. Due to the discrete character of the data, two different options for rating the border pixels are available: "pm" and "pbm". See [circumference](#) calculation for further explanation.

### Bounding box

The bounding box declares a rectangular frame which belts the object pixels without touching any of them. The left-top and right-bottom positions are calculated.

### Three dimensional results

#### Cubage

Cubage characterizes the volume of an object and is defined as the height difference between every object pixel and the object surrounding surface. The total sum of the entire height differences gives the cubage value.

#### Object minimum

The object minimum labels the object pixel with the smallest height. The x-, y- and z coordinates are available.

#### Object maximum

The object maximum names the object pixel with the largest height. The x-, y- and z coordinates are available.

#### Object mean

The object mean designates the average height of the entire object.

#### Object range

The object range names the z range of the object. The range is calculated by subtracting the minimum object height value from the maximum object height value.

#### Object standard deviation

The object standard deviation labels the standard deviation of the height values of an object.

#### Border minimum

The border minimum labels the border pixel with the smallest height. The x-, y- and z coordinates are available.

#### Border maximum

The border maximum names the border pixel with the largest height. The x-, y- and z coordinates are available.

#### Border mean

The border mean designates the average height of the object border.

#### Border range

The border range names the z range of the object border. The range is calculated by subtracting the

minimum object border height value from the maximum object border height value.

### Border standard deviation

The border standard deviation labels the standard deviation of the height values of the object's border.

### Geometry

#### Aspect ratio

The aspect ratio denotes the relation between the two main axes. The ratio is given by the length of the main first axis divided by the length of the main second axis.

#### Compactness

The compactness characterizes how much the shape of an object differs from a circle. A circle is defined by the value "1", less circular objects are rated with higher values.

The definition of compactness is given by

$$compactness = \frac{circumference^2}{(4 \cdot \pi) area}.$$

#### Fractal dimension

The fractal dimension denotes the dimension of structures with non integer values. While rectangles and cubes exhibit integer dimensions "1" respectively "2", fractals feature dimensional values in between. The fractal dimension is calculated by the box counting method. Therefore, the object is superposed by a grid. All grid elements which are occupied by object pixels are counted. The limit of the logarithmic relation between occupied grid elements N and their edge length  $\epsilon$  gives the fractal dimension value:

$$fractal\ dimension = \lim_{\epsilon \rightarrow 0} \frac{\log N(\epsilon)}{\log \frac{1}{\epsilon}}.$$

#### Elongation

The elongation characterizes the shape of an object. The more circular an object is shaped, the more the elongation converge towards zero. More elongated structures like rectangles will get values converging towards "1".

#### Orientation

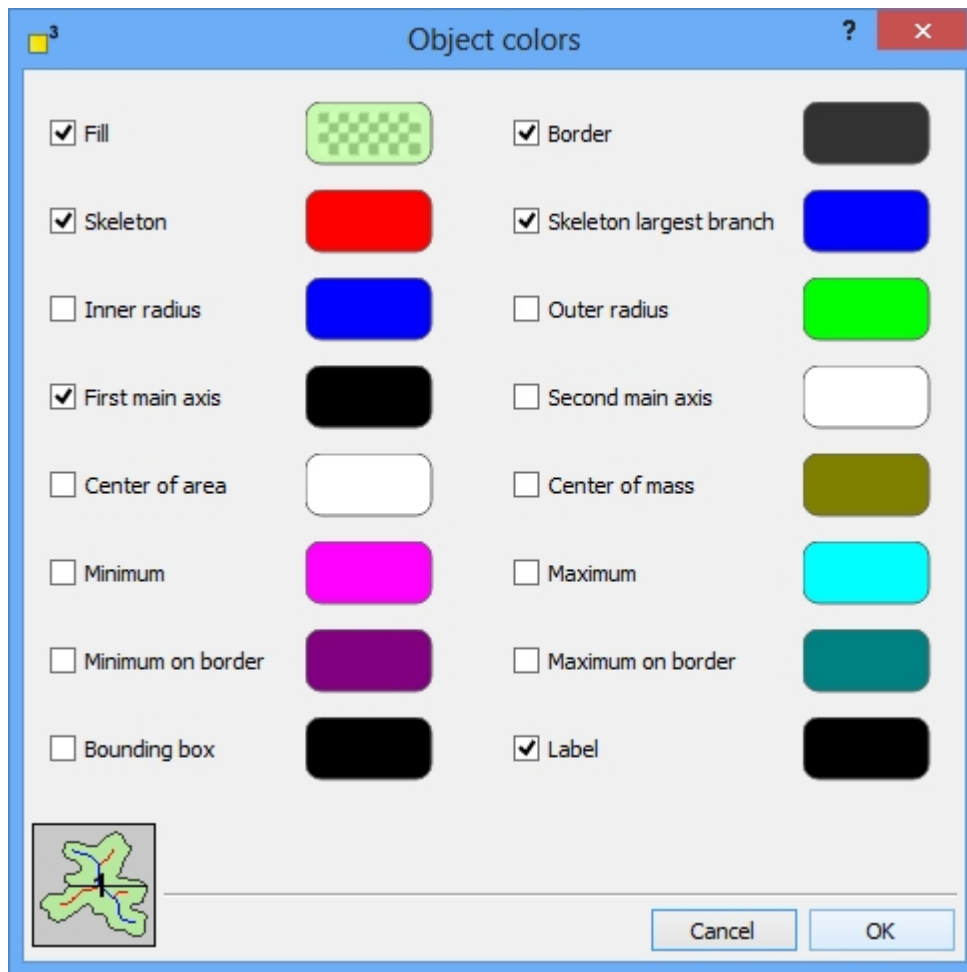
The orientation labels the angle between the x direction and the first main axis.

### Colors and labeling

The [color](#) and [labeling](#) chapter describes the settings for visualizing the analyzed data.

#### Colors

Click on the "Colors" button on the output page in the tabulator view to select which object properties should be drawn and select their color. An example is provided on the left bottom in the colors dialog. For detailed explanation of the properties see the [output values](#) section.



## Labeling

dotCube will allocate a unique numeric identification number ("**ID**") to every found object. You might modify the

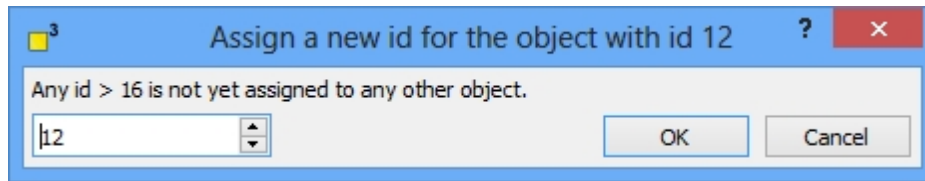
- label size
- label color and enable/disable drawing of labels and
- ID.

The label size can be changed on the output page of the tabulator view in the "**Selection and table manager**" section (see image below).



To modify the label color or switch on/off the drawing of the labels, click on the "**Colors**" button. For further explanation, see the [colors](#) section.

The IDs are allocated automatically by the object recognition function and its tracking settings. If you want to change the IDs, press CTRL and click on the object. The **ID change dialog** (see image below) will open and give you a hint which IDs are still not assigned. You might choose both, an unoccupied or an already assigned ID. In the second case, your object will get the demanded ID and the object which had this very ID previously will get the next unoccupied one.



## Object filter

The object filter assists you to concentrate on interesting features and neglect uninteresting objects. Every found object is filled into the filter list with its ID and centroid coordinates. Select any object which should be analyzed. Use the **"Select all"** and **"Deselect all"** buttons if applicable. Only the properties of selected objects are drawn and filled into tables and image headers.

**Attention:** Please note that any unselected object will not be displayed in the preview. If you cannot find your favorite objects, check the selection status in the filter list. Furthermore, read carefully the ["Selection policy"](#) section.

## Selection policy

To enable fast analysis processes dotCube has a special built-in selection policy for

- newly found objects and
- tracked objects.

The selection presets for **newly found objects** can be modified by changing the options **"Selection policy for following images"** from selected to unselected status and vice versa. If you have chosen **"unselected"**, objects which were not found in the previous image or preview will be unselected and therefore invisible. Choose **"selected"** if you would like to display any newly found objects.

**Tracked objects** are objects with the same ID in the previous image or preview. Their selection status will be transferred to the current image no matter which selection presets you had chosen. To modify their visibility and their analysis status, you have to change their selection status manually in the object filter.

**Object filter**

ID	Coordinates	Select
0	(167,48)	<input checked="" type="checkbox"/>
1	(176,88)	<input checked="" type="checkbox"/>
2	(15,90)	<input checked="" type="checkbox"/>
3	(86,108)	<input checked="" type="checkbox"/>
4	(26,155)	<input checked="" type="checkbox"/>
5	(89,156)	<input checked="" type="checkbox"/>
6	(83,192)	<input checked="" type="checkbox"/>
7	(198,203)	<input checked="" type="checkbox"/>
8	(243,231)	<input checked="" type="checkbox"/>

**Selection policy:**

Newly found object are by default

☒ Selected
 ☐ Unselected

## Tracking

The dotCube built-in tracking options force the pace of analysis processes dramatically. After selecting the objects of your interest in the first image, they are tracked in consecutive images and their data is sorted and filled in tables exactly how you need it.

According to the concept of dotCube, we provide an automatic and robust function with the chance to arrange adjustments manually. Modify the automatic tracking settings in the [tracking parameters](#) and adjust the results by [manual tagging](#).

### Tracking parameters

The tracking algorithm has to distinguish between background drift and object drift. If your objects do not move in respect to the background, select the **"Background is stable"** option. Otherwise, select the **"Background is moving"** option.

The objects in the currently analyzed image are searched within an area range corresponding to their centroid position in the previous image and their expansion. Extend this range by choosing **"additional center of object drift"** in x and y direction.

If the number of objects which could be found is constant (should be rare), choose the **"Number of objects is constant"** option. In all other cases, select the **"Changing"** option.

The case **"Moving background"** and **"Changing object numbers"** is the case with the most variability. If you want to make sure that the objects will be re-identified correctly, mark an reference object by right-

clicking on an object. This object will get the same ID in the entire analysis process and every other object will be re-identified in respect to this reference object. The coordinates are written in the box with the headline "**Ref-Object**". After a reference is marked, the previously red colored "**Ref-Object**" box will be re-colored in green. To correct your reference choice, just right click again. Only the last reference click per image is evaluated.

**Object reidentifying properties**

Background is <input type="radio"/> Stable <input checked="" type="radio"/> Moving	Additional center of object drift x= <input type="text" value="0"/> , y= <input type="text" value="0"/>	Number of objects is <input type="radio"/> Constant <input checked="" type="radio"/> Changing <input type="text" value="Ref-Object"/>
--	--	---

## Manual tagging

The **manual tagging page** is intended to assist you during **manual tracking adjustments**. On the left side, you see the previously analyzed image with the found objects. On the right side, the currently analyzed image with its objects is displayed. To change an object ID, press CTRL and left-click on an object (on Apple systems: Apple key and left-click). For further details, see the [change labels](#) section.

## Shortcut keys

The execution of the function may be started by pressing two different shortcut keys:

- **Return:** The function will be applied to all selected images.
- **Shift+Return:** The function will be applied to the next selected image only.

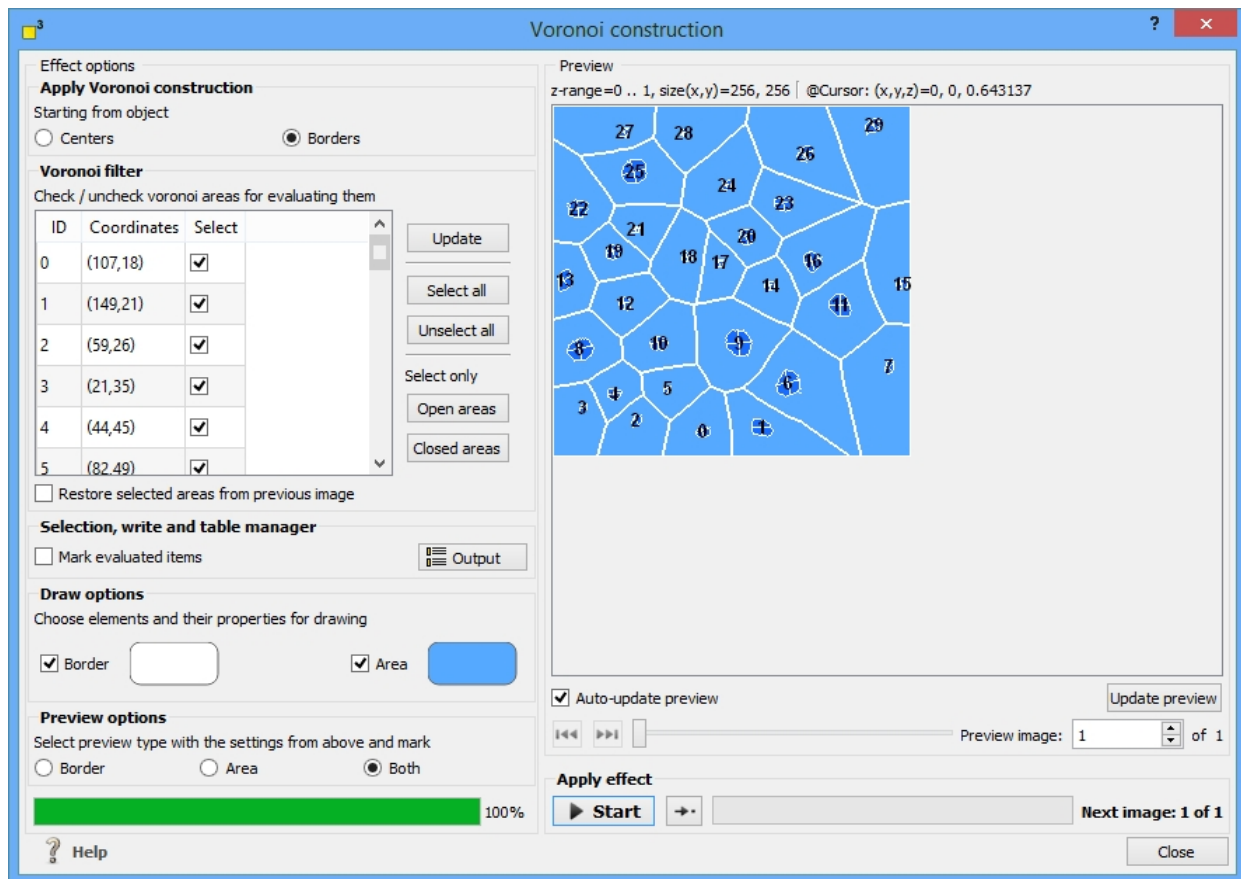
For more shortcut keys see our [detailed list](#).

## Voronoi construction

The **voronoi construction** offers great insights into the interaction of objects. It defines regions which are closest to the center object and sheds light on the influence of object shapes, distances and their interactive behavior. The voronoi construction dialog offers extensive options and analysis functions.

Read on for detailed explanation about:

- [Start configuration](#)
- [Voronoi filter](#)
- [Selection, write and table manager](#)
- [Output values](#)
- [Draw options](#)
- [Preview options](#)
- [Shortcut keys](#)



## Start configuration

The voronoi construction marks the data points which are closest to the an object. Therefore, you might start the calculation from the **object center or from object borders**. Select the applicable option in the **"Apply Voronoi construction"** group box.

## Voronoi filter

The voronoi filter displays all regions with their ID, the center coordinates and their selection status. You might select/unselect each region manually or use the buttons on the right. Thereby, **"Open areas"** means voronoi regions whose borders are not connected to the image borders. In contrary, **"Closed areas"** will select only areas which are fully encircled by other voronoi regions.

For transferring the selection status from the previous image, select the **"Restore selected areas from previous image"** option.

## Selection, write and table manager

To select the evaluated regions, choose the **"Mark evaluated items"** options. For writing and table options, click in the **"Output"** button. For further explanation see the [output values](#) section.

## Output values

Despite the write to header options, the output values dialog provides the same functionality as the output dialog in the object recognition. You might modify the tables output and/or select your favorite computed results. For further details see the [output selection dialog](#) in the object recognition function.

## Draw options

The draw options control the visualization of the voronoi areas and borders. Select which elements you want to be drawn in the origin image and modify the colors by clicking on the color buttons. The colors will be applied to both: the preview image and the origin image.

## Preview options

The preview settings control the visual output in the preview image. Select if you want the voronoi areas, borders or both to be drawn. The color settings can be changed in the [draw options](#) section.

## Shortcut keys

The execution of the function may be started by pressing two different shortcut keys:

- **Return:** The function will be applied to all selected images.
- **Shift+Return:** The function will be applied to the next selected image only.

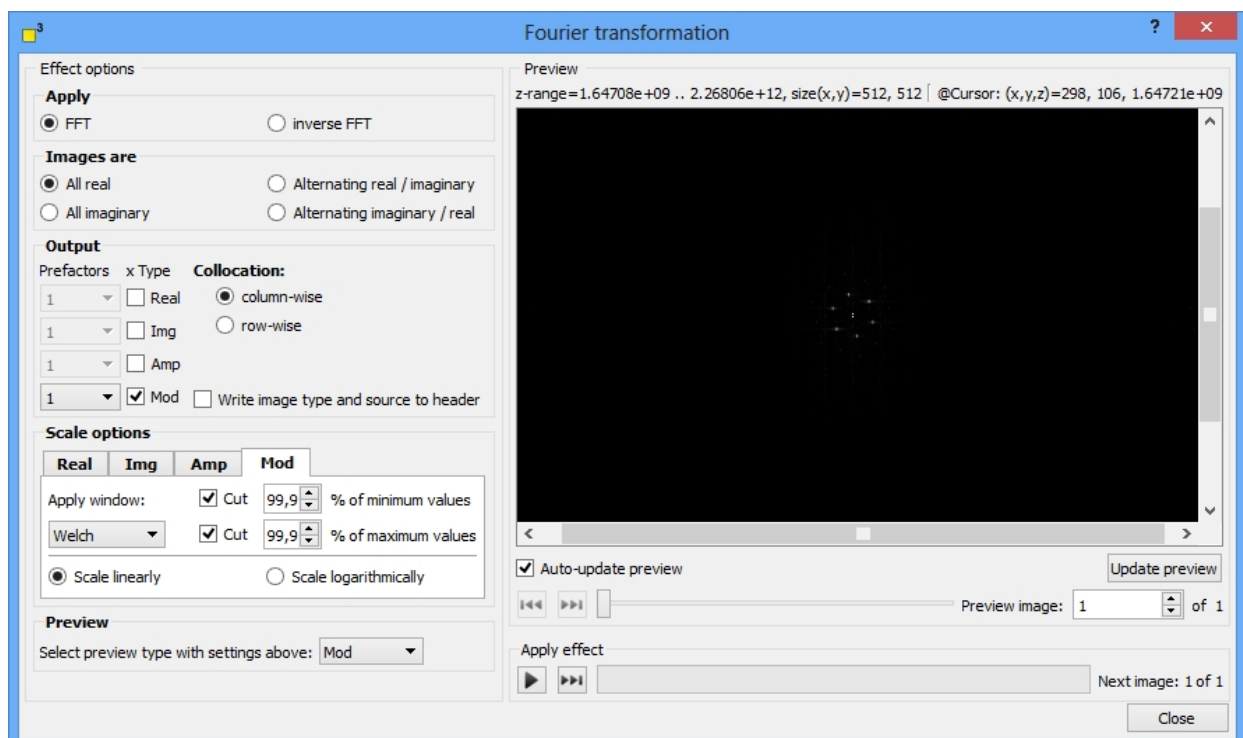
For more shortcut keys see our [detailed list](#).

## Fast Fourier transform

The **Fourier transform** is a powerful tool for analyzing wavelike or periodic structures. DotCube offers the fast Fourier transform as well as the inverse Fourier transform. Select the kind of your input data - real or imaginary - as well as the output presets and arrangements. Choose a window function and an applicable scaling of the z axis. The Fourier transform function will generate new transformed images and arrange them according to your settings.

For further details see the extensive explanation:

- [Forward or inverse Fourier transformation](#)
- [Input data](#)
- [Output data and arrangements](#)
- [Scale options](#)
- [Preview settings](#)
- [Shortcut keys](#)





## Forward or inverse Fourier transformation

DotCube offers the Fourier transformation in both directions. Select one of the **"FFT"** or **"inverse FFT"** options.

## Input data

The images might be real or imaginary data. Choose the appropriate option:

Option	Description
<i>All real</i>	All input images contain real data.
<i>All imaginary</i>	All input images contain imaginary data.
<i>Alternating real / imaginary</i>	The input image stack contains periodically initially a real data image followed by an imaginary one.
<i>Alternating imaginary / real</i>	The input image stack contains periodically initially a imaginary data image followed by a real one.

If you select one of the **"Alternating..."** options, at least two images should be available. Otherwise an error message is displayed. In this case of odd numbers, the last image will be ignored.

## Output data and arrangements

In the output group box, one or multiple kinds of transforms can be selected by checking the **"Real"**, **"Img"**, **"Amp"** and **"Mod"** options with prefactor presets.

The available targets are:

Option	Description
<i>Real</i>	The target contains only the real data part.
<i>Img</i>	The target contains only the imaginary data part.
<i>Amp</i>	The target contains the absolute values of the real data part.
<i>Mod</i>	The target contains the vector length $\sqrt{(R^2 + I^2)}$

To simplify working with large data bundles, the input images will be arranged in vertical or horizontal order. Two default collocation settings are available. The **"column-wise"** option will arrange the input images in a vertical order and any new output images column-wise. The **"row-wise"** option will put the input images in a horizontal order and arrange any new output images row-wise.

For later analysis, the Fourier function supports writing the settings and the source image names to the output image header. Select the **"Write image type and source to header"** option if applicable.

## Scale options

The scale options group box enables you to

- apply [window functions](#) to the transforms and suppress artifacts due to finite input data
- emphasis main spots by [cutting](#) values below a infimum and above a supremum
- [scale](#) the z axis linearly or logarithmically

## Window functions

Data which is not finite periodic will cause artifacts in the Fourier transforms. Therefore, window function may be applied to suppress artifacts and enhance the visibility of the main spots. DotCube offers seven most common window functions  $w(x)$ . Their behavior in real space is explained in the table below:

Window	Function
<i>Rectangular</i>	"0.5" at image borders, "1" elsewhere
<i>Hann</i>	$w(x) = 0.5 - 0.5 \cdot \cos(2\pi x)$
<i>Hamming</i>	$w(x) = 0.54 - 0.46 \cdot \cos(2\pi x)$
<i>Blackmann</i>	$w(x) = 0.42 - 0.5 \cdot \cos(2\pi x) + 0.08 \cdot \cos(4\pi x)$
<i>Welch</i>	$w(x) = 4x \cdot (1 - x)$
<i>Nutall</i>	$w(x) = 0.355768 - 0.487396 \cdot \cos(2\pi x) + 0.144232 \cdot \cos(4\pi x) - 0.012604 \cdot \cos(6\pi x)$
<i>Flattop</i>	$w(x) = 0.25 - 0.4825 \cdot \cos(2\pi x) + 0.3225 \cdot \cos(4\pi x) - 0.097 \cdot \cos(6\pi x) + 0.008 \cdot \cos(8\pi x)$

## Cutting

If applicable, you might cut all values below a lower limit (infimum) or above an upper limit (supremum). The cut values are set to the average z value. To cut the extreme values emphasize the main Fourier spots. Cutting as much values as possible leads to best Fourier spot results.

## Scaling

In linear scale the Fourier spots might be poorly visible. Select the "Scale linearly" or "Scale logarithmically" to define the scaling of the z axis.

## Preview settings

The preview window displays only one possible Fourier transform. Select your favorite transform to preview in this group box.

## Shortcut keys

The execution of the function may be started by pressing two different shortcut keys:

- **Return:** The function will be applied to all selected images.
- **Shift+Return:** The function will be applied to the next selected image only.

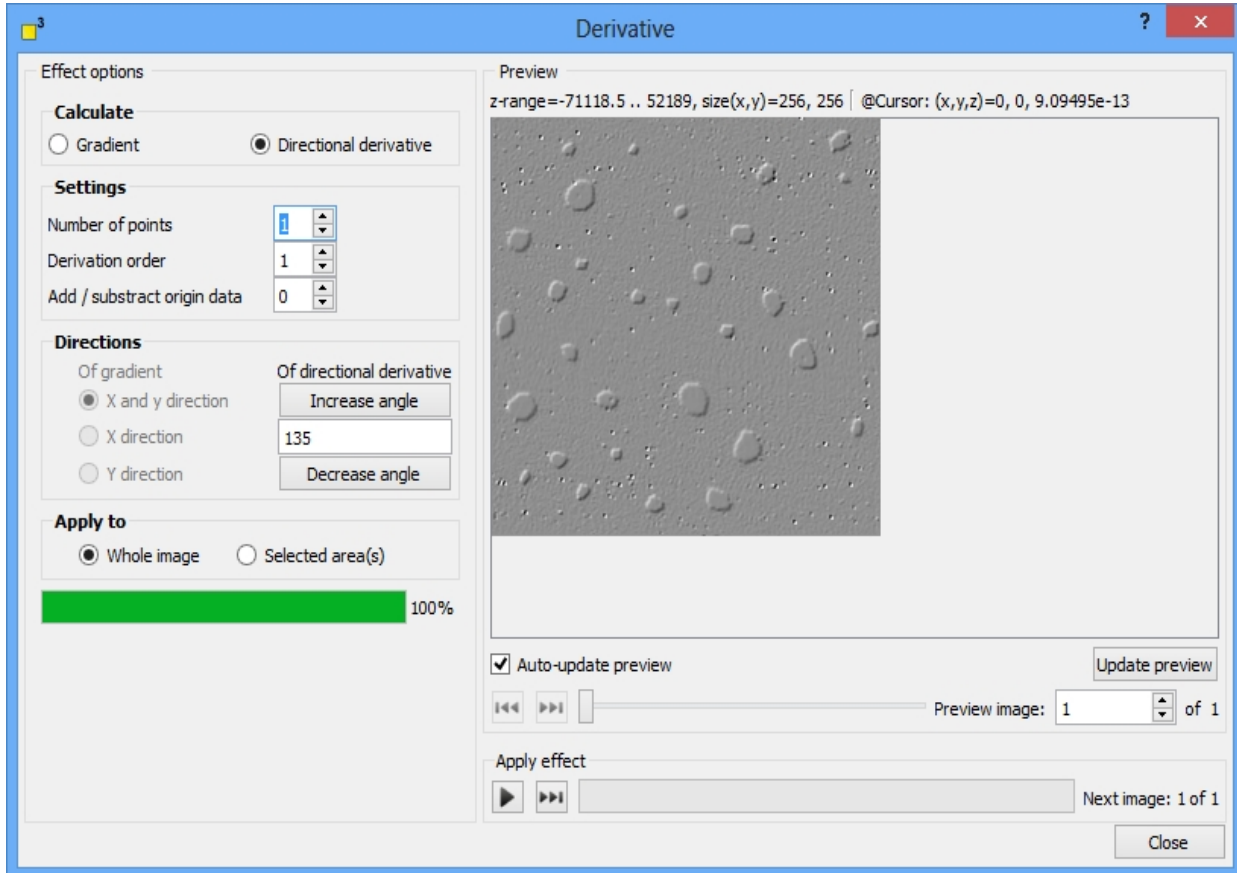
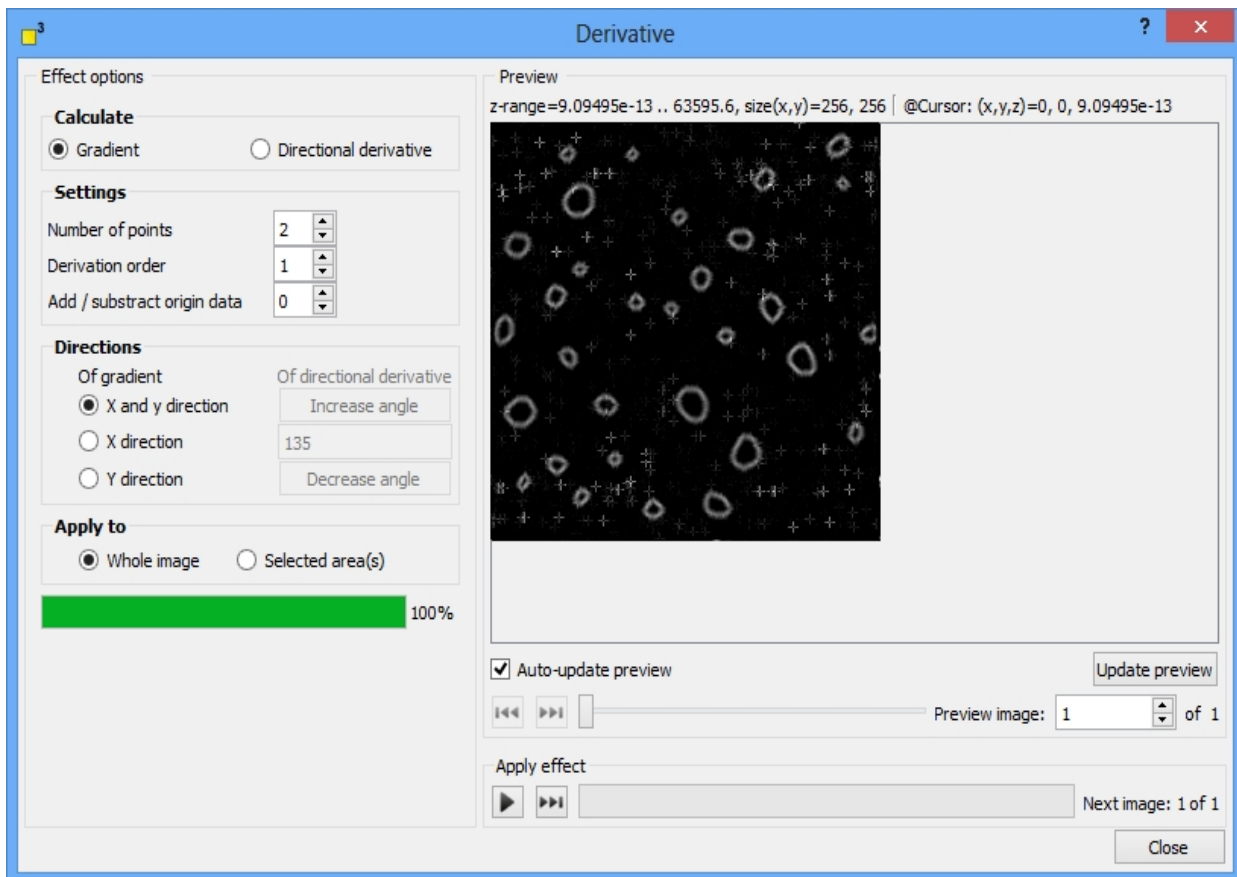
For more shortcut keys see our [detailed list](#).

## Derivative

The derivative function offers two complimentary derive functions - gradient and directional derivative. The gradient derivative creates a vector field pointing into the direction of the largest slope. Its length is plotted in the processed image. The directional derivative visualize the slope in one or more directions. As a consequence it creates a visual shading of structures and emphasizes structural features.

Read on for detailed explanation about:

- [Derive functions](#)
- [Settings](#)
- [Directions](#)
- [Where to apply](#)
- [Shortcut keys](#)



## Derive functions

DotCube provides two derive functions: **gradient** and **directional derivative**. The gradient derivative creates a vector field pointing into the direction of the largest slope. Its length is plotted in the processed image. The directional derivative visualize the slope in one or more directions. As a consequence it creates a visual shading of structures and emphasizes structural features. Select the applicable option in the **"Calculate"** group box.

## Settings

The derive settings options are shown in the table below:

Option	Description
<i>Number of points</i>	Number of neighboring points which contribute to the calculation.
<i>Derivation order</i>	Number of consecutive derivations.
<i>Add / subtract origin data</i>	The origin data multiplied with this factor is added to the processed image.

Note: If the **number of points** is increased, the features in the processed image are more emphasized and measurement noise will be reduced, but the processed image loses its sharpness.

## Directions

For the gradient calculations, the x and y **direction** as well as both are available. For the directional derive calculation, any angle with a step size of 45° is selectable.

## Where to apply

Choose the region where the derive functions should be applied: to the entire image or to a previous marked area. Select the applicable option.

## Shortcut keys

The execution of the function may be started by pressing two different shortcut keys:

- **Return**: The function will be applied to all selected images.
- **Shift+Return**: The function will be applied to the next selected image only.

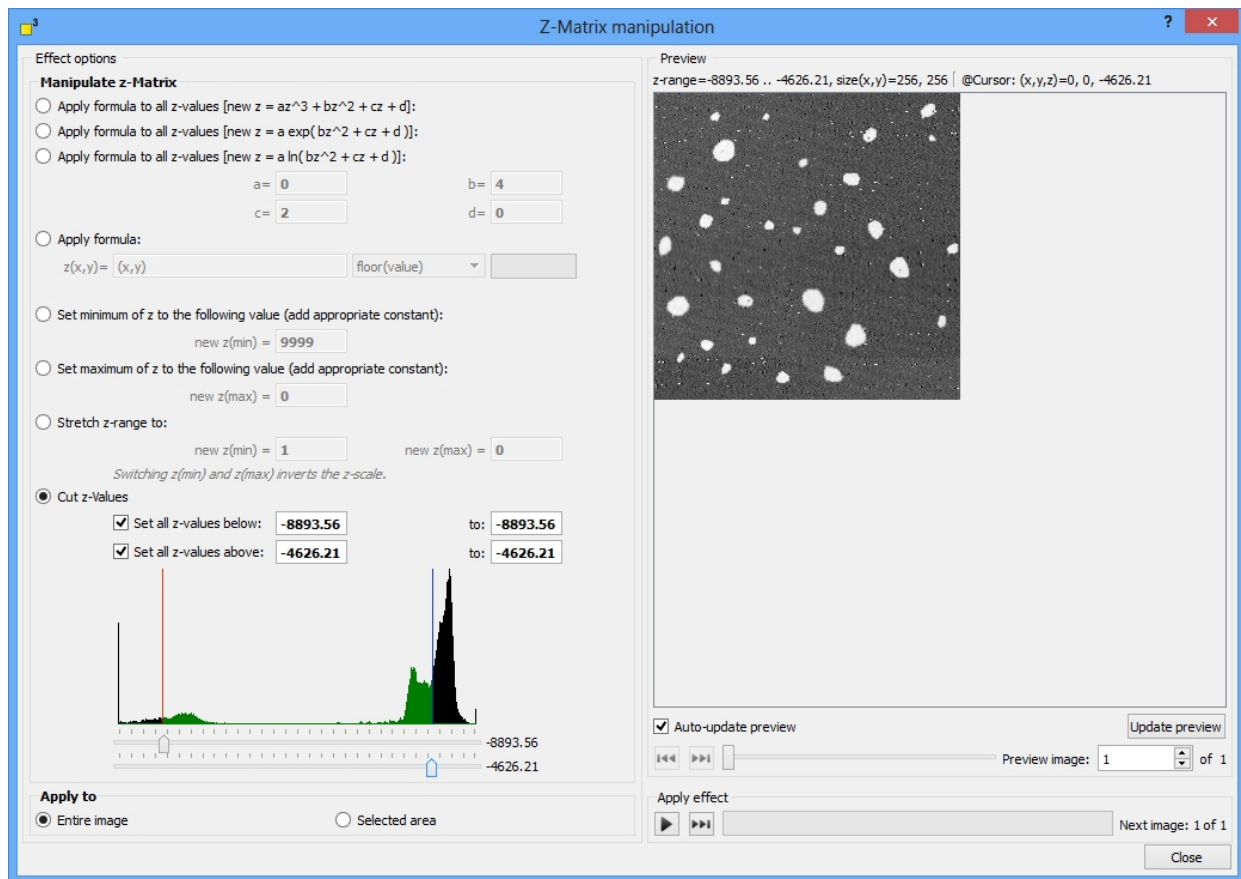
For more shortcut keys see our [detailed list](#).

## Z matrix manipulation

The z matrix manipulation function enables the user to modify the z range, apply default or custom formulas to the data and cut extreme values. The usage of this function will improve the results of the [object recognition](#) function as well as the [thinning](#) tool.

For detailed explanation see

- [Apply default formulas](#)
- [Apply custom formulas](#)
- [Set minimum and maximum](#)
- [Stretch / squeeze z range](#)
- [Cut z range](#)
- [Shortcut keys](#)



## Apply default formulas

Three default kinds of formulas are available:

- polynomial
- exponential
- natural logarithmic.

Select the applicable option and specify the constants a to d.

## Apply custom formulas

Custom formulas can be created by selecting the **"Apply formula"** option. Insert any mathematical expression and use the built-in mathematic functions if necessary. Consider, the deploy of your function to the z matrix may consume some time depending on the z matrix dimensions. A progress bar to the right keeps you informed.

## Set minimum and maximum

The **minimum** and **maximum** functions set a new lower respectively upper limit. The entire z matrix data is shifted appropriate to the new limits. E.g.: If the z matrix contains image data between "0" and "1" and you set the new minimum to "1", the new z range will be from "1" to "2".

## Stretch / Squeeze z range

The **"Stretch z range to"** function stretches or squeezes the previous z range into the new custom one. The contrast of your images will not change, only the z value range is modified.

## Cut z range

The **"Cut z values"** function modifies the z values and changes the image contrast as well contrary to the [minimum/maximum](#) and [stretch](#) functions. The histogram displays the height distribution within the image. Adjust the two sliders below to specify the demanded lower and upper cut limit. The cut values are black colored, the others are green colored. The upper and lower limit is set accordingly to your selection. The limit values are shown in the display elements above the histogram. Every value exceeding the limits is set to exactly to the limit if you have checked this option. Hence, this function may enhance the contrast of your images. Otherwise, deselect these options if you do not want to change the contrast of your images but simply cut z values.

## Shortcut keys

The execution of the function may be started by pressing two different shortcut keys:

- **Return:** The function will be applied to all selected images.
- **Shift+Return:** The function will be applied to the next selected image only.

For more shortcut keys see our [detailed list](#).

## Transform mask to object

The "Transform mask to object" function converts selected pixels into a single or into multiple objects.

Read on for further details:

- [Create one or multiple objects](#)
- [Choose object ID manually or automatically](#)
- [Output options: values, colors and labels](#)

### Create one or multiple objects

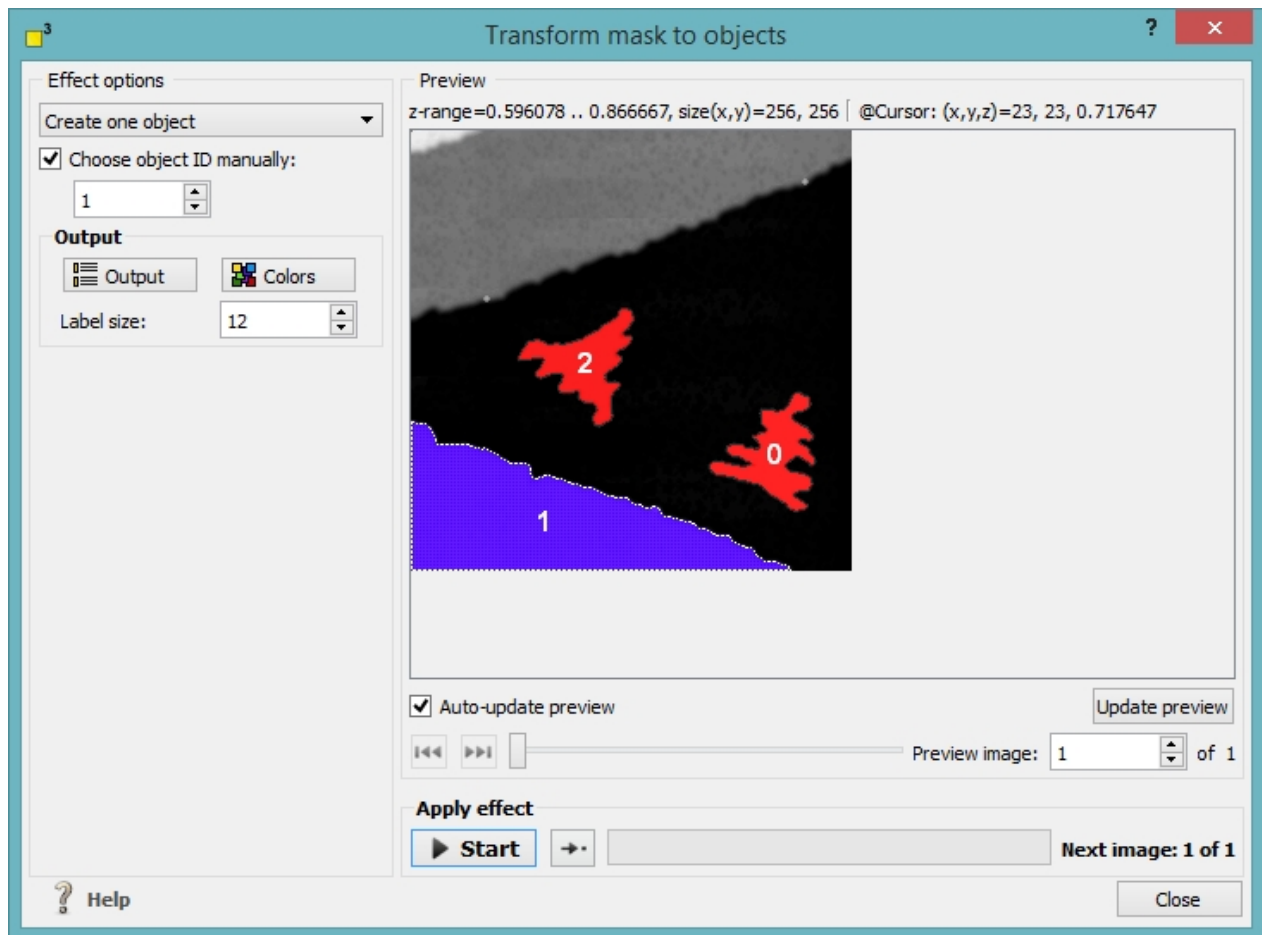
The "Create one object" option will allocate every selected pixel to a single object no matter if the selected pixels are adjacently. If you would like to assign only contiguous pixels to an object, choose the "Create one object per part" option.

### Choose object ID manually or automatically

If this option is unselected, the dotCube software assign automatically a still not used ID to the newly created objects. If you decide to allocate an ID manually, the pixels converted to an object get the demanded ID and duplicated IDs are avoided by automatically renaming them.

### Output options: values, colors and labels

The output options of the "Transform mask to object" function are various and the similar to the [output options](#) of the [object recognition](#) function. Read a detailed description in the "[Object recognition](#)" section in the [image processing](#) chapter.



## Effects

dotCube provides an extensive selection of effects to highlight structures and objects of your interest. Even customized effects can be created, stored and applied. Select one of the many default effect schemes or play around with a [convolution matrix](#) in the matrix dialog window.

Read on for further detailed information about

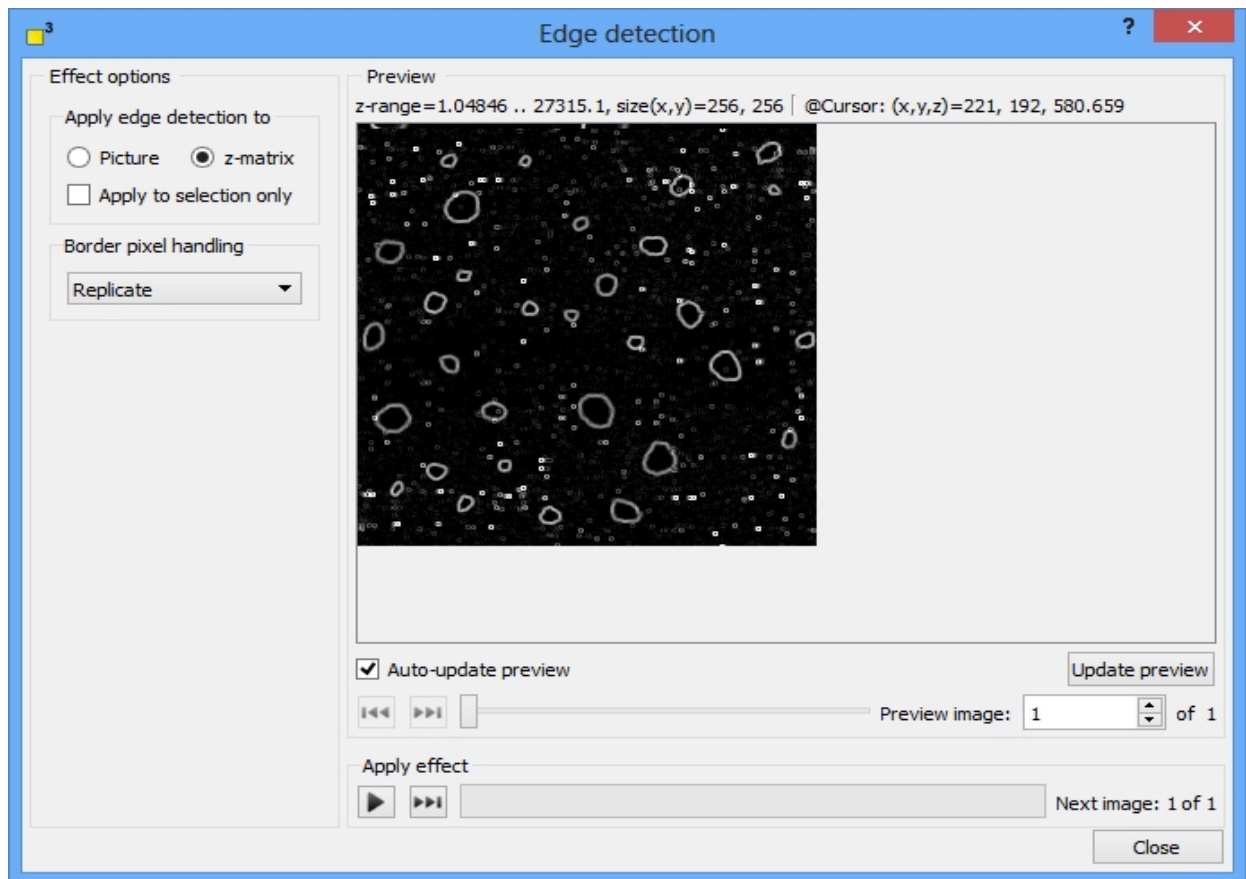
- [Edge detect](#)
- [Gaussian blur](#)
- [Unsharp mask](#)
- [Thinning](#)
- [Matrix convolution](#)

### Edge detect

The edge detect function embosses sudden changes in the z matrix or picture data and suppresses slight changes. Hence, the processed image is colored black except at structural features. The effect may be applied to the z matrix as well as to picture data. The effect is comparable to the [gradient derivative](#).

Read on for detailed explanation about

- [Input data](#)
- [Where to apply](#)
- [Border pixel handling](#)
- [Shortcut keys](#)



## Input data

Picture data as well as the z matrix data are appropriate. Select therefore the **"Picture"** or **"Z-matrix"** option.

## Where to apply

The effect can be applied to the entire image or to a previously selected region. Uncheck or check the option **"Apply to selection only"**.

## Border pixel handling

The effect compares a current analyzed pixel with its neighbor pixels. At the image borders the missing neighbor pixels can be handled in two different ways:

- **Replicate**: The missing neighbor pixels are duplicated from their mirror-inverted counterpart within the image dimensions.
- **Wrap around**: The origin image will be duplicated and periodically attached to itself. Thus, dealing with image borders is avoided. But note: This option should not be applied to tilted images because height differences might overcast the features of your interest.

## Shortcut keys

The execution of the function may be started by pressing two different shortcut keys:

- **Return**: The function will be applied to all selected images.
- **Shift+Return**: The function will be applied to the next selected image only.

For more shortcut keys see our [detailed list](#).

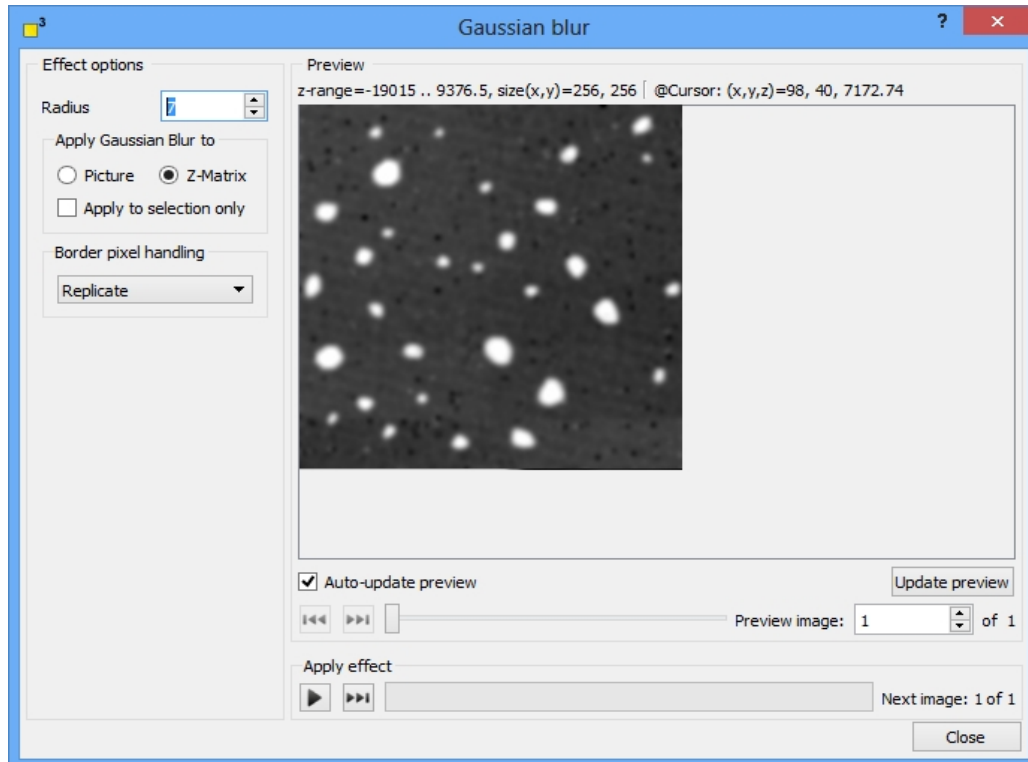


## Gaussian blur

The Gaussian blur effect provides an blurring tool for picture as well as for z matrix data. The effect buries artifacts due measurement noise and distortions.

Read on for detailed explanation about

- [Input data](#)
- [Where to apply](#)
- [Settings](#)
- [Border pixel handling](#)
- [Shortcut keys](#)



### Input data

Picture data as well as the z matrix data are appropriate. Select therefore the **"Picture"** or **"Z-matrix"** option.

### Where to apply

The effect can be applied to the entire image or to a previously selected region. Uncheck or check the option **"Apply to selection only"**.

### Settings

The radius defines the number of neighbor pixels which are taken into account. A higher number leads to higher blur and vice versa.

### Border pixel handling

The effect compares a current analyzed pixel with its neighbor pixels. At the image borders the missing neighbor pixels can be handled in two different ways:

- **Replicate:** The missing neighbor pixels are duplicated from their mirror-inverted counterpart within the image dimensions.
- **Wrap around:** The origin image will be duplicated and periodically attached to itself. Thus, dealing with image borders is avoided. But note: This option should not be applied to tilted images because height differences might overcast the features of your interest.

## Shortcut keys

The execution of the function may be started by pressing two different shortcut keys:

- **Return:** The function will be applied to all selected images.
- **Shift+Return:** The function will be applied to the next selected image only.

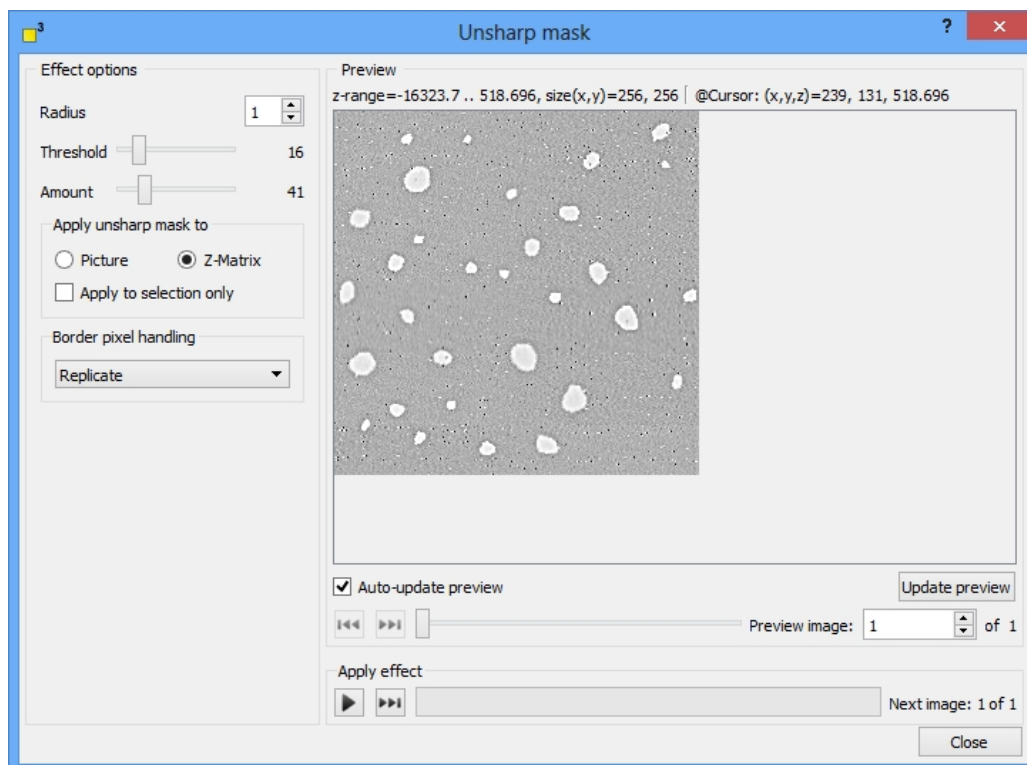
For more shortcut keys see our [detailed list](#).

## Unsharp mask

This effect provides a sharpening tool for picture as well as z matrix data. Blurred edges can be resolved and really small structures emphasized (see the tiny features inside the holes in the image below).

Read on for detailed explanation about

- [Input data](#)
- [Where to apply](#)
- [Settings](#)
- [Border pixel handling](#)
- [Shortcut keys](#)



## Input data

Picture data as well as the z matrix data are appropriate. Select therefore the **"Picture"** or **"Z-matrix"** option.

## Where to apply

The effect can be applied to the entire image or to a previously selected region. Uncheck or check the option **"Apply to selection only"**.

## Settings

The **"Threshold"** defines a lower limit from which the effect should be applied. The **"Amount"** value controls the strength of the applied effect.

## Border pixel handling

The effect compares a current analyzed pixel with its neighbor pixels. At the image borders the missing neighbor pixels can be handled in two different ways:

- **Replicate**: The missing neighbor pixels are duplicated from their mirror-inverted counterpart within the image dimensions.
- **Wrap around**: The origin image will be duplicated and periodically attached to itself. Thus, dealing with image borders is avoided. But note: This option should not be applied to tilted images because height differences might overcast the features of your interest.

## Shortcut keys

The execution of the function may be started by pressing two different shortcut keys:

- **Return**: The function will be applied to all selected images.
- **Shift+Return**: The function will be applied to the next selected image only.

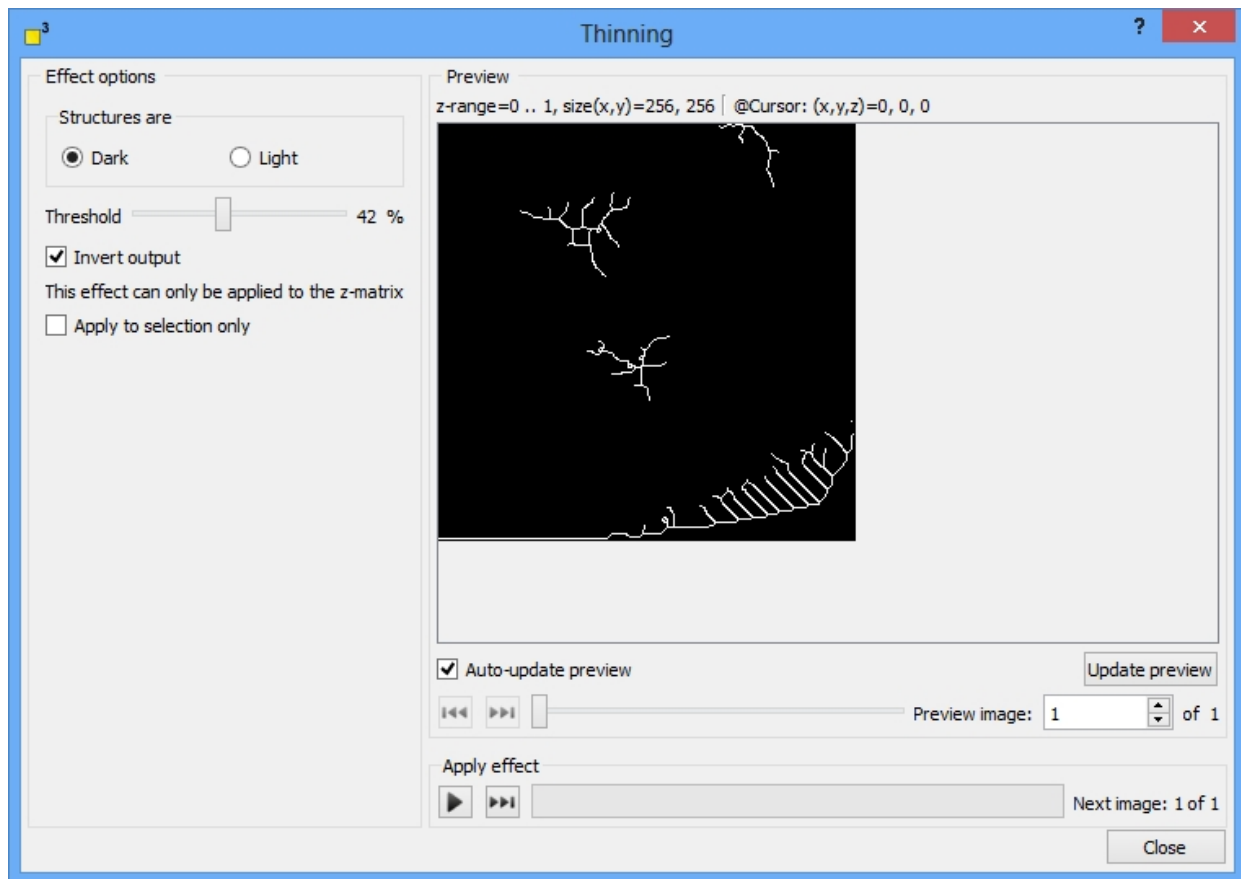
For more shortcut keys see our [detailed list](#).

## Thinning

The thinning effect shrinks structures to their main structural features comparable to an image of a human body reduced to its skeleton. The effect processes the darkest or the brightest image elements. To analyze thinned structures, see the [output values](#) in the object recognition section. We strongly suggest to apply the "Z matrix manipulation" tool and limit the z scale to the main features of your interest for best results.

Read on for detailed explanation about

- [Input data](#)
- [Where to apply](#)
- [Settings](#)
- [Border pixel handling](#)
- [Shortcut keys](#)



## Input data

Only z matrix data is appropriate.

## Where to apply

The effect can be applied to the entire image or to a previously selected region. Uncheck or check the option **"Apply to selection only"**.

## Settings

Specify if the darkest or brightest structures should be processed by selecting the **"Dark"** or **"Light"** option. Define the limit of the processed data by adjusting the **"Threshold"** slider. If you would like to invert the colors, check the **"Invert output"** option.

**Note:** We strongly suggest to apply the **"Z matrix manipulation"** tool and limit the z scale to the main features of your interest before you apply the thinning effect. This guarantees best results.

## Border pixel handling

The effect compares a current analyzed pixel with its neighbor pixels. At the image borders the missing neighbor pixels can be handled in two different ways:

- **Replicate:** The missing neighbor pixels are duplicated from their mirror-inverted counterpart within the image dimensions.
- **Wrap around:** The origin image will be duplicated and periodically attached to itself. Thus, dealing with image borders is avoided. But note: This option should not be applied to tilted images because height differences might overcast the features of your interest.

## Shortcut keys

The execution of the function may be started by pressing two different shortcut keys:

- **Return:** The function will be applied to all selected images.
- **Shift+Return:** The function will be applied to the next selected image only.

For more shortcut keys see our [detailed list](#).

## Matrix convolution

The matrix convolution enables the user to apply customized effects to picture and z matrix data. Additionally, dotCube offers seven default effects and provides the possibility to store permanently your custom matrix presets.

Read on for detailed explanation about

- [Understanding the convolution matrix](#)
- [Changing matrix elements](#)
- [Storing custom presets](#)
- [Applying matrix presets](#)
- [Handling of border pixels](#)
- [Selecting data channels](#)
- [Where to apply](#)
- [Settings](#)
- [Shortcut keys](#)

Effect options

Matrix Presets: Emboss ▾ Save preset Delete preset

0	0	0	0	0
0	-2	1	0	0
0	-1	1	1	0
0	0	1	2	0
0	0	0	0	0

Edge mode: Replicate Edge Pixel ▾ Divisor: 0

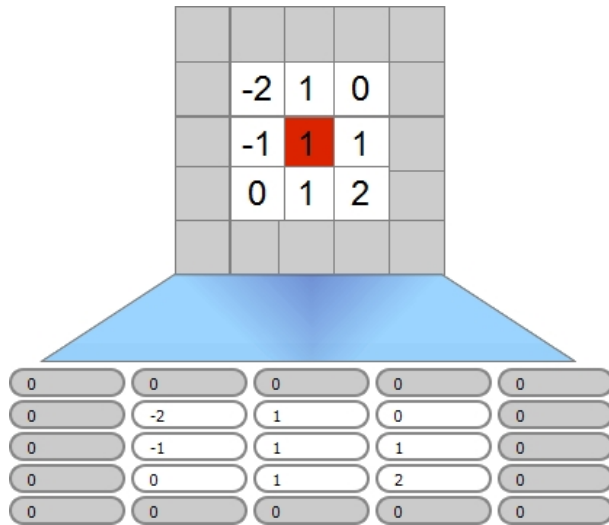
Channels: ☒ Red ☒ Green ☒ Blue ☒ Alpha ☒ Z ☐ Lock Z Matrix Dynamic

☐ Apply to selection only

## Understanding the convolution matrix

Although the design of the convolution matrix may appear complicated, its adaption is very simple. The matrix contains white and gray matrix element boxes. Merely the white boxes are applied to the data.

So how do we convolute the matrix with the data?



The simplest way to explain is the superposition of the matrix with the data pixels. If we want to process our custom effect to pixel "a" (the red colored pixel in the middle of the image above), we apply the sum of each neighbor pixel multiplied by a factor from the corresponding matrix element to pixel a.

E.g.: We want to apply the "emboss" effect with the matrix elements above to pixel a. So we start on top of the start pixel and go around clockwise:

processed pixel =  $1 \cdot \text{pixel}(1,1) + 0 \cdot \text{pixel}(1,1) + 1 \cdot \text{pixel}(1,0) + 2 \cdot \text{pixel}(1,-1) + 1 \cdot \text{pixel}(-1,0) + 0 \cdot \text{pixel}(-1,-1) - 1 \cdot \text{pixel}(-1,0) - 2 \cdot \text{pixel}(-1,1) + 1 \cdot \text{start pixel}$ .

How to proceed at the image borders, see [handling of border pixels](#).

## Changing matrix elements

Click on a matrix element box to insert a value. All element boxes of the same square will change their color to white and contribute to the matrix convolution.

## Storing custom presets

After you have modified the matrix elements, you might store the matrix settings. Click on the button "**Save preset**". The save dialogs prompts a preset name. After the preset is saved, you can select your preset from the "**Matrix presets**" bar.

## Applying matrix presets

Select your favorite preset from the "Matrix preset" bar. The convolution matrix will be filled with the associated factors.

## Handling of border pixels

The effect compares a current analyzed pixel with its neighbor pixels. At the image borders the missing neighbor pixels can be handled in two different ways:

- **Replicate**: The missing neighbor pixels are duplicated from their mirror-inverted counterpart within the image dimensions.
- **Wrap around**: The origin image will be duplicated and periodically attached to itself. Thus, dealing with image borders is avoided. But note: This option should not be applied to tilted images because height differences might overcast the features of your interest.

## Selecting data channels

The matrix convolution effect can be applied to picture and / or z matrix data. Choose the channels you want to manipulate ("**red**", "**green**", "**blue**", "**alpha**" and "**z**").

## Where to apply

The effect can be applied to the entire image or to a previously selected region. Uncheck or check the option "**Apply to selection only**".

## Settings

The "**Divisor**" will be applied to picture as well as z matrix data. All processed data will be divided by this factor. If the divisor is set to "0", no divisor will be applied.

The "**Lock z matrix dynamic**" will hold the range of the z matrix constant. Therefore, the convolution matrix will modify the z matrix within its range and thereby change the contrast of your image. But the z range remains unchanged.

## Shortcut keys

The execution of the function may be started by pressing two different shortcut keys:

- **Return**: The function will be applied to all selected images.
- **Shift+Return**: The function will be applied to the next selected image only.

For more shortcut keys see our [detailed list](#).

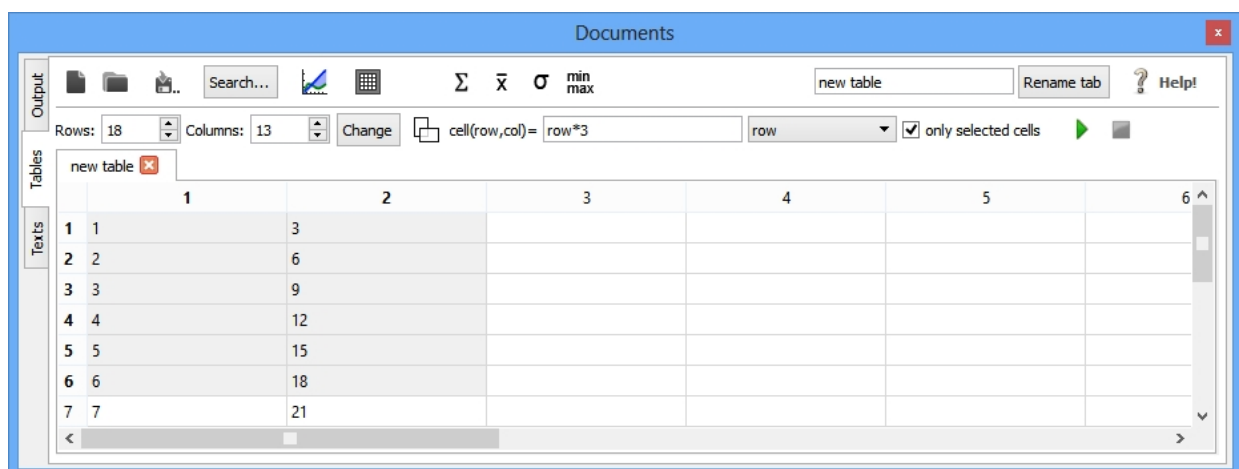
## Spreadsheets

The spreadsheet section in the lower section of the dotCube window consists of three major elements:

- [Output page](#)
- [Tables page](#)
- [Text page](#)

The output page displays results of dotCube functions, the tables page provides the mathematical functionality of spreadsheets and the text page enables you to make and store your own notes. Each page can be saved and exported in several ways.

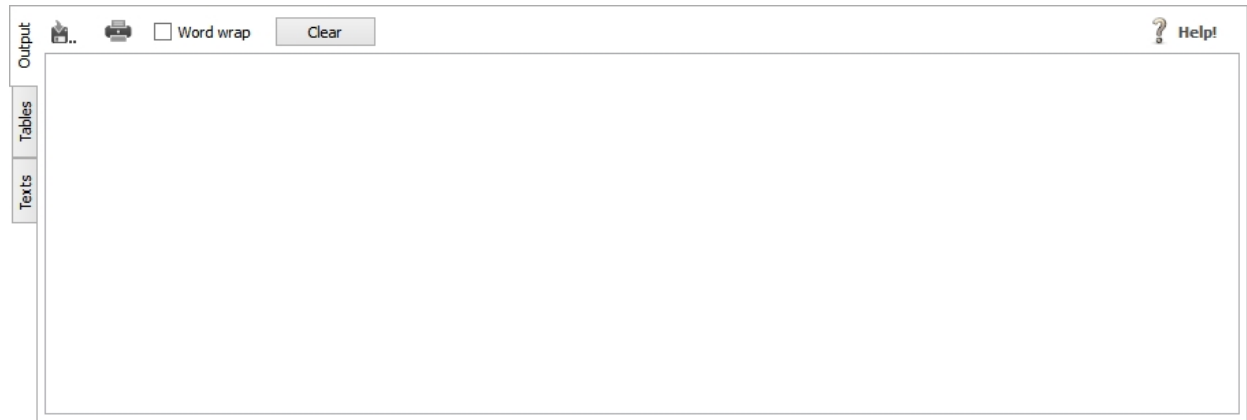
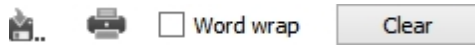
Go to the [next chapters](#) for detailed explanations.



## Output page

The output page displays the results of dotCube tools in the icon bar, for example the line scan tool. You might

- save as a text file
  - print
  - clear
- the current output page.

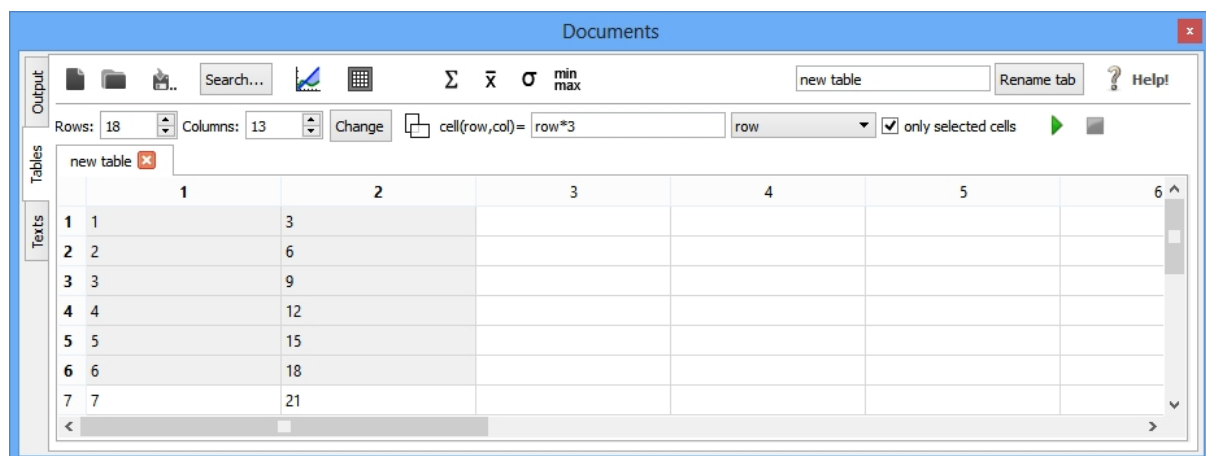


## Tables page

Beside the common handling functions of the other pages like open, save, export, search and replace, the tables page provides extensive spreadsheet functions.


Read on for further details:

- [Table handling](#)
- [Mathematical and statistical functions](#)
  - [Sort](#)
  - [Apply formulas](#)
    - [Example 1: Fill a column with its row numbers](#)
    - [Example 2: Multiply a column by a factor](#)
  - [Statistical functions](#)
  - [Find correlations](#)
- [Two dimensional plots](#)
- [Convert data to z matrix](#)



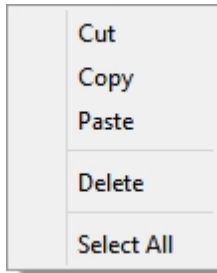
## Table handling




To create a new table, specify the numbers of rows and columns click onto the **"New table"** button. 

Rows:  Columns:

For cut, copy, paste, delete and select options, use the right click menu.



Click on the "Search" button to search and replace elements in the current table.

 Search:   ☐ Case-sensitive  
Replace:

## Mathematical and statistical functions

Use the tables page to work with your data. After creation of your customized table, apply formulas and calculate significant statistical values.

### Sort

Data displayed in tables can be sorted by clicking on a column header. Dependent on the amount of mouse clicks, the data is sorted ascending and descending alternately. The entire table is sorted in respect to the column where the click ensued.

### Apply formulas

The formula input panel "cell(row,col)=" enables you to process complicated calculations. Insert a formula and use some of the default functions if necessary. Select if your formula should be applied to selected cells only or to all cells and press "play".

See two examples below:

- [Fill a column with its row numbers](#)
- [Multiply a column](#)



### Fill a column with its row numbers

To fill a column with its row numbers, select empty cells and insert the formula:

$cell(row,col) = \$row$

in the formula panel and press "play". Every variable or function has to get a "\$" sign as an escape sign.

The cells will be filled with the values: 1, 2, 3, ...

## Multiply a column by a factor

To multiply a column filled with its row numbers by a factor of "3", select empty cells to the right of the origin column and insert the formula:

$$\text{cell}(\text{row}, \text{col}) = \text{cell}(\$row, \$col-1)*3$$

in the formula panel and press "play".

The origin column contains the values: 1, 2, 3, ...

and the results are: 3, 6, 9, ...

## Statistical functions

On table page you are able to calculate statistical values easy and fast. Just click on the applicable button. The results are displayed on the [output](#) page.

Available functions are:

- Sum
- Average
- Standard deviation
- Minimum and maximum values

$\Sigma$   $\bar{x}$   $\sigma$   $\begin{smallmatrix} \text{min} \\ \text{max} \end{smallmatrix}$

## Find correlations

The "Find correlations" functions helps looking for dependencies within your table data. The algorithm calculates the formula, determines errors and creates plotable data of the approximated functions.

To find correlations, proceed as follows:

1. Mark the data cells which should be checked for dependencies. The correlation function assumes that single data channels are placed columnwise.
2. Select the type of functions which should be approximated and adjust the speed-quality ratio for higher polynomial orders. These are determined by an statistical approach.
3. Choose your required type of result:
  1. Correlations: The dependencies of any column against any other column is calculated.
  2. Plotable data of the approximated functions: This feature creates a lookup table of approximated functions with a reasonable stepsize for plotting. Therefore, define the columns of your origin values and their functional counterpart as well as the extreme values and the demanded step size. Specify your expected precision of the outputted values.
4. Press start to begin.



## Two dimensional plots

Mark at least two columns and click on the "Plot" button. A plot dialog opens and enables you to define your own plot settings. For further details see the "[Two dimensional plots](#)" section in the [plotting](#) chapter.



## Convert data to z matrix

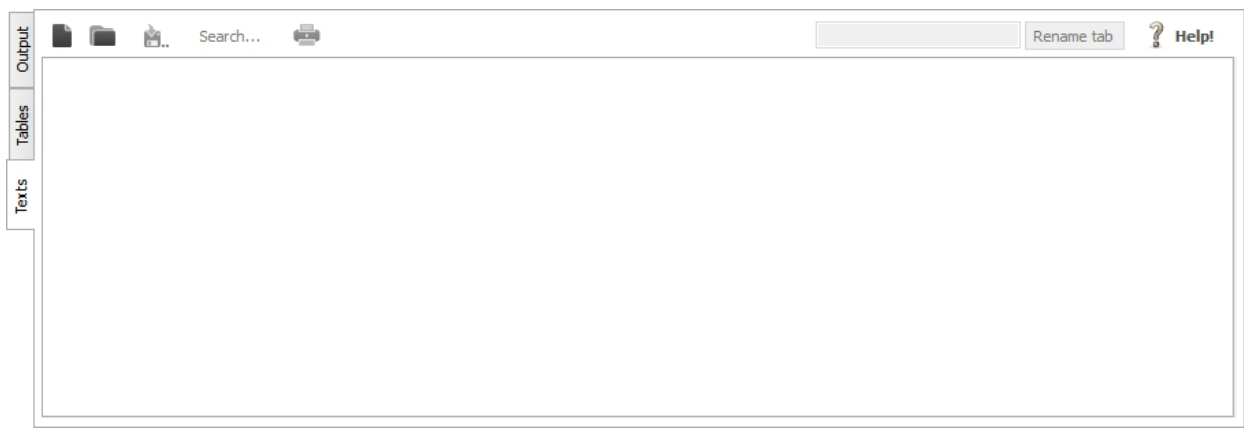
Each table might be converted to a z matrix. Therefore, mark the requested table data cells and click on the "Create image from selected cells" button. An image is created consisting of the selected table data as the z matrix.



## Text page

The text page offers space for your notes. Write every annotations you like and save or export them as a text file. You might also

- organize your note in several tabs
- search and replace keywords
- rename tabs
- open previously stored files
- save and export your notes
- print.




## Search and Replace

Click on the "Search" button to search and replace elements on the current table or text page.



## Plotting

The plotting section in  enables you to create [two dimensional](#) as well as [three dimensional](#) plots. [Two dimensional plots](#) help you to visualize results which are given in tables in the [spreadsheet](#) section. [Three dimensional plots](#) provide you with a new point of view on your data, empower your imagination and close the gap between simple scan data and reality. For detailed explanation see the following chapters.

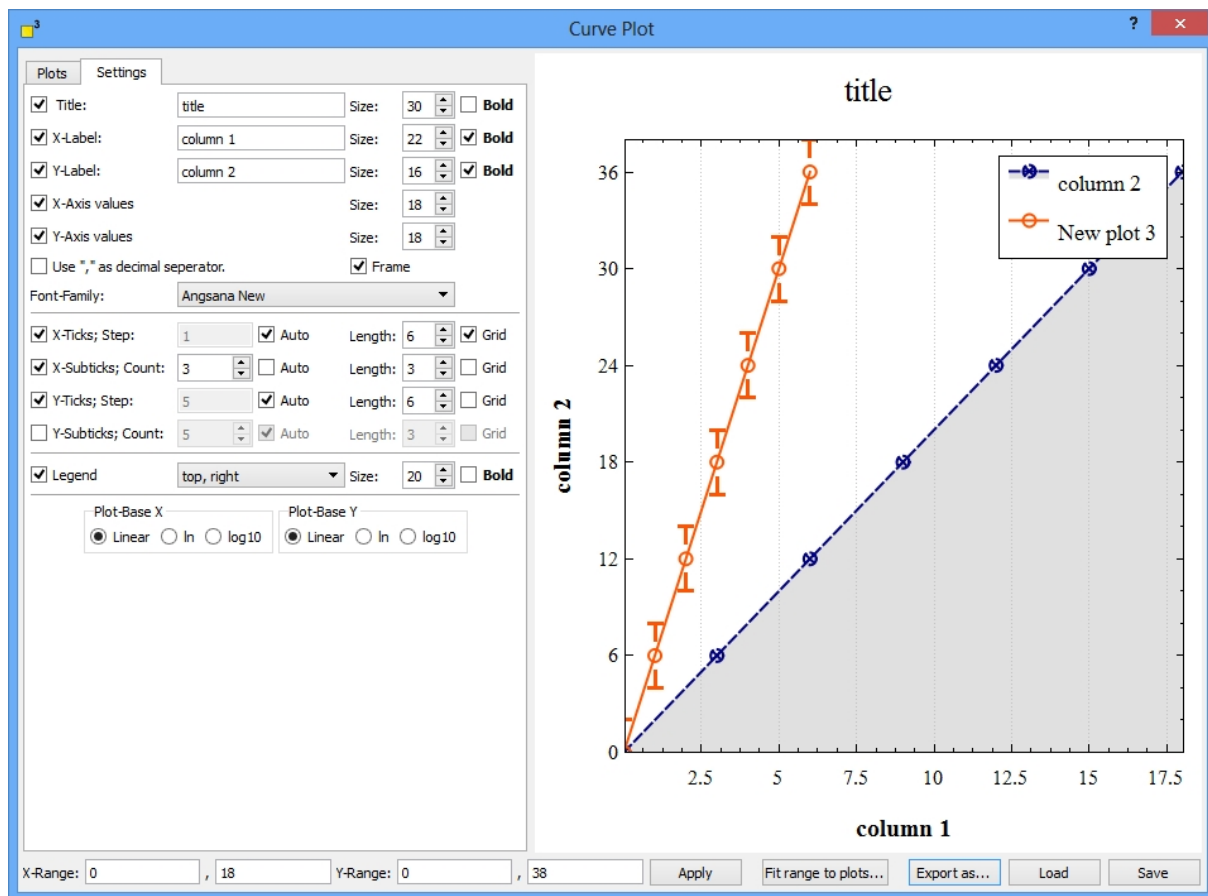
## 2-dimensional plots

The two dimensional plot section provides extensive options to create customized plots and visualize your data.

Read on for further explanation:

- [Transfer data from tables into the plot dialog](#)
- [Plot filter page](#)
- [Plot options](#)
  - [Plot data](#)


- [Plot settings](#)
- [Error settings](#)
- [Visibility](#)
- [Graph settings page - title, labels, legend and bases](#)
  - [Title and labels](#)
  - [Ticks and sub-ticks](#)
  - [Legend](#)
  - [Plot bases](#)
- [Range, export, load and save options](#)
  - [Range](#)
  - [Export](#)
  - [Load and save](#)



## Transfer data from tables into the plot dialog


Mark any data cells which you want to transfer into the plot dialog. The data from the tables is copied into the plot function. The plot dialog presents a plot suggestion: The first column is interpreted as x data, any other columns are plotted in respect to the first one. You might delete, add and modify any of them on the plot filter page or create new ones.

The following example will create two plots from three marked columns which can be modified or deleted later in the plot dialog window.

plotable table 

	1	2	3	4
1	1	1	-1	
2	2	4	-8	
3	3	9	-27	
4	4	16	-64	
5	5	25	-125	
6	6	36	-216	

This second example will not create any plot because no data tuple with the same row index is marked.

plotable table 

	1	2	3	4
1	1	1	-1	
2	2	4	-8	
3	3	9	-27	
4	4	16	-64	
5	5	25	-125	
6	6	36	-216	

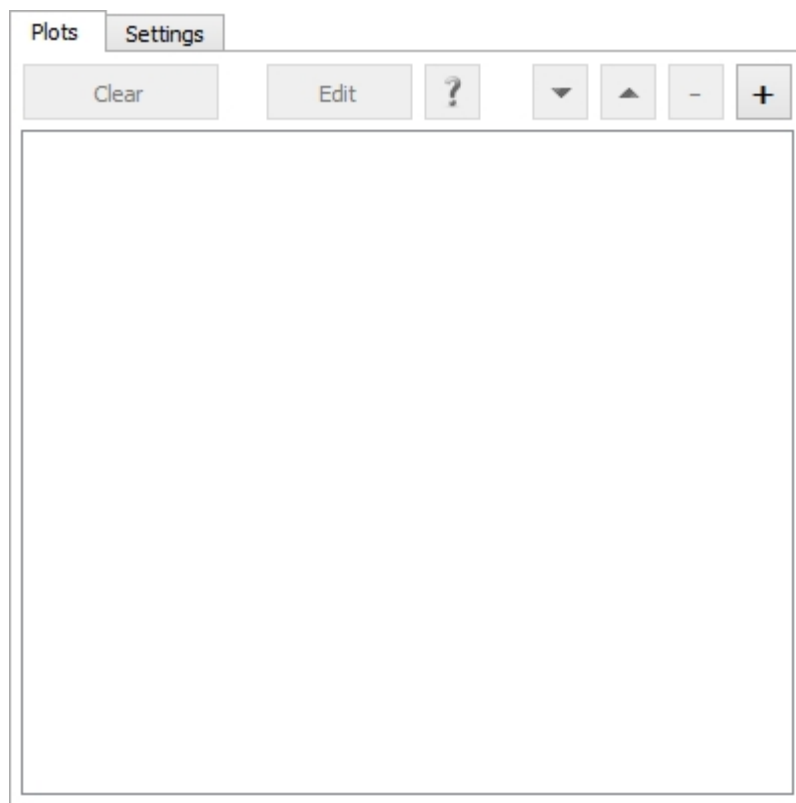
**Note:** Once the data from the table is copied into the plot dialog, any changes of the table data will not modify your plots.



## Plot filter page

The plot filter page provides an overview of the currently created plots. First its name is shown followed by the column number of the y and x data.

- Create new plots by clicking in the "plus" button
- To modify existing plots double click on them or click the "Edit" button
- Delete a single plot by marking it and clicking the "minus" button
- Delete all plots by pressing the "Clear" button
- To change the order click on the "up" or "down" buttons
- To output characteristic values of any plot mark its label and press the "question mark" button. The values are displayed on the output page in the spreadsheet section.



## Plot options

When you create a new plot from the plot filter dialog or modify an existing one, the plot options dialog is shown. It enables you to define the

- [Plot data](#)
- [Plot settings](#)
- [Error settings](#)
- [Visibility](#).

**Plot options**

**Plot-Data**

**X-values:** column 1 **Y-values:** column 4

Positive X-errors: [none] Positive Y-errors: [none]

Negative X-errors: [none] Negative Y-errors: [none]

**Plot-Options**

Plot title (legend): column 4

Plot color:   ☐ Fill area between x-axis and line. Color:  

☒ **Show dots** Dot size: 5 Dot style: X

☒ **Show line** Line Width: 1 Line style: —

**Errors**

☐ **Show X-error bars**

**X-error**

Add constant error: Plus: 0 Minus: 0

Add percentage error: Plus: 0,000 Minus: 0,000

☐ **Show Y-error bars**

**Y-error**

Add constant error: Plus: 0 Minus: 0

Add percentage error: Plus: 0,000 Minus: 0,000

**Error options**

Plot color:   ☒ Error bar skip symbol

Line Width: 1 Line style: solid Bar size: 10

? Help ☒ Plot visible Cancel OK

## Plot data

Define the location of your x and y data and optional the error data.

**Plot-Data**

**X-values:** column 1 **Y-values:** column 4

Positive X-errors: [none] Positive Y-errors: [none]

Negative X-errors: [none] Negative Y-errors: [none]


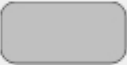
## Plot settings

Label your plot and choose its appearing color. Select if the area between the plot and the y axis should be filled and colorize it.

Specify if the dots or the line is displayed and define their size and style.

**Plot-Options**

Plot title (legend):

Plot color:  ☒ Fill area between x-axis and line. Color: 

☒ **Show dots** Dot size:  Dot style:

☒ **Show line** Line Width:  Line style:

## Error settings

Activate the optional error bars and specify a constant or percental error or even both. The error bars might be asymmetric as you might choose different error bars for plus and minus. Select the error bar color, line width, line style and bar size.

**Errors**

☐ **Show X-error bars**

**X-error**

Add constant error: Plus:  Minus:

Add percentage error: Plus:  Minus:


☐ **Show Y-error bars**

**Y-error**

Add constant error: Plus:  Minus:

Add percentage error: Plus:  Minus:

**Error options**

Plot color:  ☒ Error bar skip symbol

Line Width:  Line style:  Bar size:

## Visibility

You might hide or display plots by deselecting or selecting the visibility flag at the left bottom of the dialog.

☒ **Plot visible**

## Graph settings page - title, labels, legend and bases

The graph settings page structures the properties for

- title and labels
- Ticks and sub-ticks
- legend
- plot bases.



Plots

Settings

☐ Title:  Size:  ☒ Bold

☒ X-Label:  Size:  ☐ Bold

☒ Y-Label:  Size:  ☐ Bold

☒ X-Axis values Size:

☒ Y-Axis values Size:

☐ Use "," as decimal separator. ☒ Frame

Font-Family:

☐ X-Ticks; Step:  ☒ Auto Length:  ☒ Grid

☐ X-Subticks; Count:  ☒ Auto Length:  ☐ Grid

☐ Y-Ticks; Step:  ☒ Auto Length:  ☒ Grid

☐ Y-Subticks; Count:  ☒ Auto Length:  ☐ Grid

☒ Legend  Size:  ☐ Bold

Plot-Base X  
☒ Linear ☐ ln ☐ log10

Plot-Base Y  
☒ Linear ☐ ln ☐ log10

## Title and labels

This section sets the properties for titles and labels. Activate the title or labels and name them. Define their size, style and their font family. When you use "," as a decimal separator, activate this option.

## Ticks and sub-ticks

The ticks and sub-ticks properties are arranged in the middle of the settings page. Select which kind of ticks or sub-ticks you prefer and specify their number manually or automatically. A grid might be added to the plot window. Define which ticks or sub-ticks should be emphasized and activate the appropriate check-boxes.

## Legend

For each plot a legend can be created automatically if requested. Place the legend at one out of eight default spots and specify its size and style.

## Plot bases

Three kind of plot bases for the x and y axes are available: linear, natural logarithm and decadic logarithm. Select the appropriate option.

## Range, export, load and save options

You find the range, export, load and save options at the bottom part of the plot dialog.

X-Range:  ,  Y-Range:  ,

## Range

Set the minimum and maximum values of each axis and press the "Apply" button. You might use the automatic option "Fit range to plots..." or turn the mouse wheel as well.

## Export

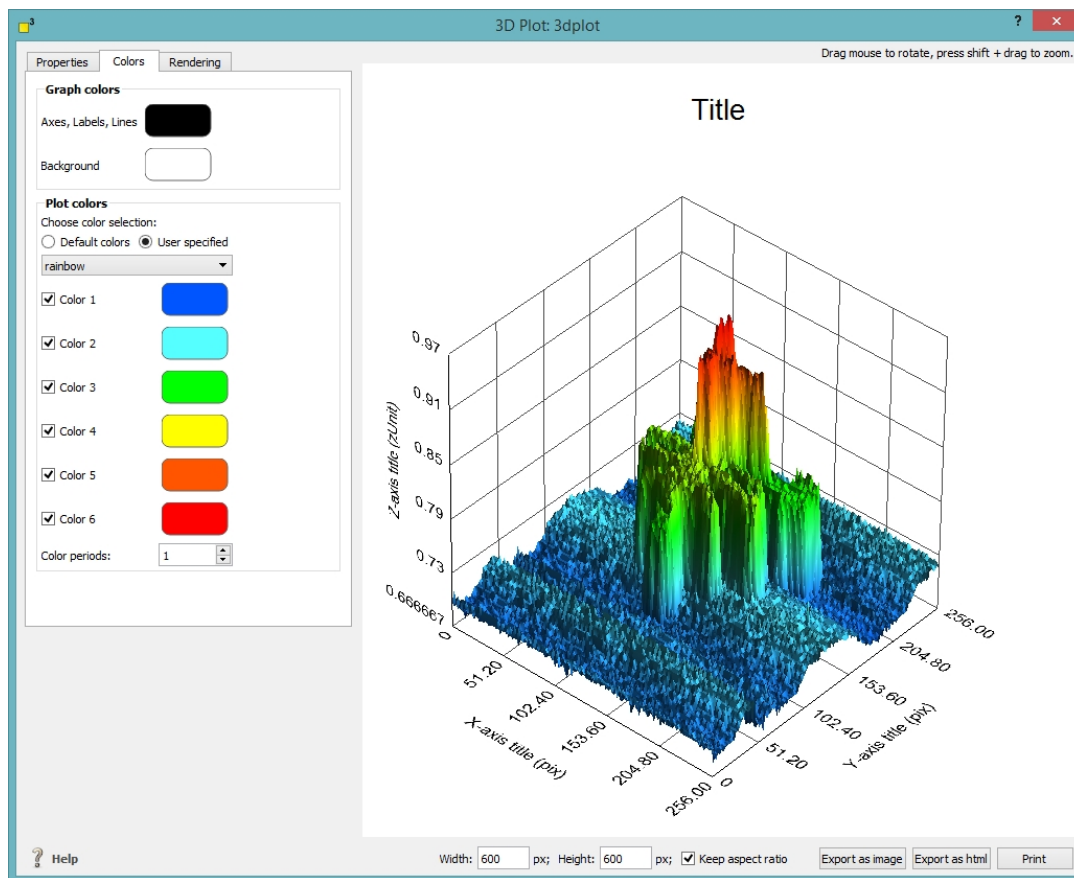
The plot dialog offers the possibility to export the current plot as pdf, png, bmp and jpeg files. Click on the "Export as..." button and select the applicable file type.

## Load and save

With the help of the load and save functions, you are able to store your plots in the dotCube format on hard disk.

## 3-dimensional plots

The major control elements for [creating 3d plots](#) are in a tabulator view with pages for [properties](#), [colors](#) and [rendering](#). The control elements for [export](#) and printing of the existing plots are located at the bottom of the window.



## Create three dimensional plots

**3** offers extensive three dimensional drawing options. To simplify the creation of these plots, **3** provides a lot of default settings. All options are neatly arranged on three pages which are explained in the following: [properties](#), [colors](#) and [rendering](#).

### The properties page

The properties page consists of an "[Axis and titles](#)" and a "[Scaling](#)" section.

### The Axis and titles section

**Axis and titles**

☒ Graph title:

☒ X axis title:  ☒ X unit

☒ Y axis title:  ☒ Y unit

☒ Z axis title:  ☒ Z unit

Select font family, size in pixels and style:

Comic Sans MS  bold

In the "Axis and titles" section you choose the titles and labels of your graph and all axes. Check or uncheck each label to customize your graph. You might add units automatically to the axes labels by checking the unit checkboxes. Select the font family, its size and style of all graph descriptions.

### The scaling section

The axes labels and their style are set in the "Scaling" section.

**Scaling**

☒ in pixels ☐ in natural units

☒ X ticks Count:  ☐ Subticks

Select numerical format and precision:

Normal

☒ Y ticks Count:  ☐ Subticks

Select numerical format and precision:


Normal

☒ Z ticks Count:  ☐ Subticks

Select numerical format and precision:

Normal

☐ Use "," as decimal separator.

At the top choose if you would like to display the axes values in pixels or natural units. Select which axes  should create and how many ticks and subticks should be drawn. For each axis the numerical style (normal: "1.2345" and scientific: "1.23 $\times 10^{45}$ ") and the precision of the tick labels. Depending on your local settings, choose the decimal separator.

### The colors page

The colors of your three dimensional plot are set on the "color" page. In the upper section you select the colors of axes, labels and lines as well as the colors for the background.

**Graph colors**

Axes, Labels, Lines 

Background 

**Plot colors**

Choose color selection:

☐ Default colors ☒ User specified

rainbow ▼

☒ Color 1 

☒ Color 2 

☒ Color 3 

☒ Color 4 

☒ Color 5 

☒ Color 6 

Color periods:  ▲ ▼

The colors for representing the data are displayed in the section "Plot colors". First, you have to choose if you would like to transfer the color scheme from the origin Scilmage. If you decide to use self-specified colors you might select one of our default color schemes or pick up to six colors on your own. You may use less than six colors. In this case, uncheck the unnecessary colors.

The option at the bottom of this section helps you to use more than six colors in your plot. The number of color periods describes the number of iterations how often the above selected colors reoccur in your color scale.

## The rendering page

The rendering page contains all the settings which emphasize the three dimensional experience of your plot. it consists of the "[Data precision and render mode](#)" section, the "[Lighting](#)" section and the "[View](#)" section.

**Data precision and render mode**
☐ Auto  
 Precision: 1 / 2    
☒ Use webGL  
☐ Render data points


**Lighting**
 Ambient light options:  
 Brightness (%): 150    
 Scheme: white   
 Spot light options:  
 Brightness (%): 100    
 Direction (X,Y,Z): 1,0   0,0   1,0

**View**
 Select angle in respect to z-axes:  
 X angle: 70   Y angle: 42    
 Shift plot in x and y direction:  
 X: 0   Y: 80    
 Zoom: 102

### Data precision and render mode

The first section "Data precision and render mode" sets the options in respect to your hardware layout. Depending on your computational system and its graphics equipment you should decrease the number of evaluated data points.

**Data precision and render mode**
☐ Auto  
 Precision: 1 / 2    
☒ Use webGL  
☐ Render data points

If the default setting "Auto" is activated, <sup>3</sup> limits the number of evaluated data points to 14400 points. If you decide to vary this data limit, you might uncheck the "Auto" option and select your favorite precision. A precision of 1/2 means every second data point will be drawn, 1/3 every third and so forth.

If your web browser support webGL you should check this option. WebGL enables smoother handling and significant better drawing of the three dimensional plots. Only if no webGL is available, you might select the rendering of each data point depending on the power of your hardware.

### Lighting

Similar to openGL options, webGL offers extensive lighting options. We have to distinguish between two kinds of light sources: the [ambient light](#) and the [spot light](#).

**Lighting**

Ambient light options:

Brightness (%):

Scheme:

Spot light options:

Brightness (%):

Direction (X,Y,Z):

## Ambient light

The ambient light is a diffuse light source and provides a background lighting comparable to the sun light. You might select up to 1000% of brightness and chose a favored ambient light scheme. Four default light schemes are available.

Ambient light scheme	Description
<i>white</i>	All fraction of primary colors are equally distributed.
<i>sunlight</i>	The light drifts slightly into the yellow similar to the natural sunlight.
<i>warm</i>	All colors are slightly shifted into the red region.
<i>cold</i>	All colors are slightly shifted into the blue region.

## Spot light

The spot light is a directional light source comparable to a huge spotlight and enhances structural differences on the surface. The brightness is adjustable (up to 1000%) as well as the spot direction. The spot direction vector is normalized to the length of the axes. Try different directional settings to emboss any special surface feature you like.

## View

Customize the appearance of your three dimensional plot by selecting your favorite perspective.

**View**

Select angle in respect to z-axes:

X angle:  Y angle:

Shift plot in x and y direction:

X:  Y:

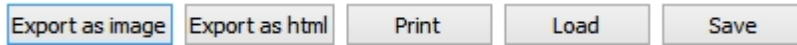
Zoom:

You might rotate your plot by selecting different angles, shift the plot in x- and y-direction as well as define a default zoom factor. All settings are default settings. You may vary these values at any time by your mouse controls.

Mouse and keyboard commands	Description
<i>Click and rotate</i>	Rotate the plot in three dimensions.
<i>Press "shift" and drag.</i>	Zoom in or out.

## Export three dimensional plots

■<sup>3</sup> offers several possibilities to store and export your plots. It is possible to create [images files](#), [html files](#) as well as [pdf documents](#). For posterior analysis the plots can be stored in the ■<sup>3</sup> file format.



## Export and print settings

Before exporting your data as an image or pdf file or before printing, you should specify the dimensions of your plot. Select your favorite dimensions in pixels and check or uncheck the "Keep aspect ratio" to avoid unwanted stretching of your plot.

Width:  px; Height:  px; ☒ Keep aspect ratio

## Export as an image file or pdf document

Specify your favored [image dimensions](#) and [click on the "Export as image" button](#) to export your plot as an image file or pdf document. ■<sup>3</sup> supports the file formats png, jpg and pdf.

## Export as an html document

With ■<sup>3</sup> it is fast and simple to create html source code for a web site. [Click on the "Export as html" button](#) and select a folder. Inside this folder, the main html file will be created along with several sub folders containing associated javascript and css documents.

## Print your three dimensional plots

Printing your plots with ■<sup>3</sup> is really easy. [Specify the image dimensions](#) and [click on the "Print" button](#). In the print dialog window, you are able to select your printer with all its settings.

## Export

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dotCube provides extensive export functions and in this way enables you to work fast and time-efficient with your results. The several export functions consist of three main categories:

- [Numeric results](#)
  - [Tables, output and texts](#)
  - [Z matrices](#)
  - [Object, skeleton and mask pixels](#)
- [Graphical results](#)
  - [Images and layers](#)
- [Evolution in time](#)
  - [Movies](#)

Please keep in mind: If you own a free educational license of the dotCube software, the export functions are disabled.

## Numeric results

### Tables, output and texts

Tables, output tabs and text tabs are stored together with the project file. Optional, you might store or export them separately as a dotCube (\*.table.cube, \*.output.cube, \*.text.cube) or text file (\*.txt). To start with

the export, press the save button on top of the current tabulator view.

## Z matrices

The z matrix contains the measurement data of every image. The origin data may be modified by some functions of the dotCube software for example some features of the [image processing](#) section ([plane correction](#), [z manipulation](#), [derivative](#), [fast fourier transformation](#), ...), the [effects](#) section and the [Right-click menu](#) (Z matrix → [Map picture to z matrix](#), [recalibrate z matrix](#)). The current z matrix is exportable via the file menu (File → Export selected → z matrices).

## Object, skeleton and mask pixels

Several dotCube analysis functions determine pixels of [objects](#) and their [skeleton](#) which are stored inside the object layer of the regarding image. Despite calculated pixels, every image contains a mask [layer](#) which stores any selected pixel. These pixels are exportable via the file menu (File → Export selected → Objects pixels / Objects' skeleton pixels / Objects' largest skeleton branch pixels / mask pixels).

The object pixels are written into a text file as tab separated values with a header line consisting of

1. image name
2. object ID
3. x in pixel units
4. y in pixel units
5. x in origin units
6. y in origin units
7. z in origin units
8. boolean value if the pixel belongs to a selection ("0" means "does not belong to a selection" and "1" vice versa)

The mask pixels are written into a text file as boolean values ("0" means "not selected", "1" means "selected") without any separator in between. These boolean values are a representation for each image pixel and indicate if this one is selected or is not selected.

## Graphical results

### Images and layers

Images with or without their [layers](#) are exportable via the file menu (File → Export selected → Images with display elements / Images without display elements). To enable or disable distinct [layers](#) (e.g. object or mask layer), see the "[Advanced Properties](#)" dialog. For modifying the display elements, switch to the "[Display properties](#)" settings in the [icon bar](#).

Images with display elements are exportable both as \*.png and \*.pdf files, images without display elements only as \*.png files.

## Evolution in time

### Movies

Some structural changes in microscopy images are only obvious if these images are presented within a short time interval - for example as a movie. Therefore, dotCube provides the possibility to export image sequences as a movie file. To begin with the export as a movie, select the appropriate option from the file menu (File → Export selected images as movie).

The movie export dialog asks about the frames per second (a higher number will decrease the time per image and vice versa) and how long the last frame should be kept or shown. If you would like to export selected images without creating a movie file, select the "Generate images only" option. To start the movie export, press the OK button.



