

# Contour Match XNC

Plug-In



## Copyright

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Version 6.2.5  
Neckarstraße 76-1, 71686 Remseck, Germany

Phone: +49 (0) 7146 - 89 56-0  
Fax: +49 (0) 7146 - 89 56-29  
E-Mail: [info@neurocheck.com](mailto:info@neurocheck.com)  
Web: [www.neurocheck.com](http://www.neurocheck.com)

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## Introduction

### About NeuroCheck plug-in DLLs in general

A plug-in DLL is a .NET assembly meeting the NeuroCheck plug-in-interface specifications. It serves to enhance NeuroCheck with user-defined image processing functionality and custom menu entries.

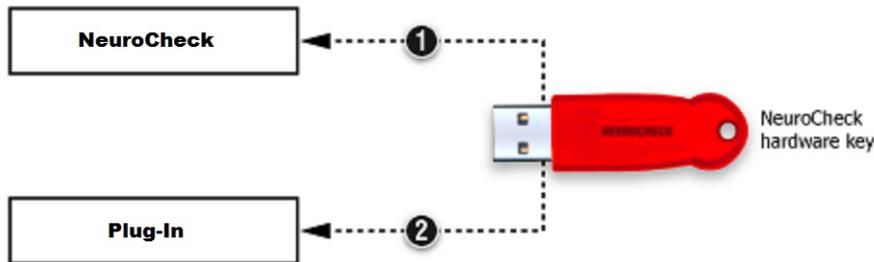
Please note that for integration of a plug-in check function into your check routine, a Premium license is required. The completed check routine then can be run with any NeuroCheck license (except the Demo Version).

### About this Plug-In

The Plug-In PI\_ContourMatchXNC integrates a contour based search algorithm to NeuroCheck to find objects in image scenes. It's application is similar to Template Matching. Learn more about the Plug-In check function Match Model Contour, for example it's benefits against Template Matching (in [Introduction](#)), about how it works (in [How To Use](#)) or get a quick start (in [Check Routine Sample](#)).

## Licensing

This section describes the licensing mechanism for the NeuroCheck Plug-In **PI\_ContourMatchXNC.NET**.



### 1. Protection of NeuroCheck

NeuroCheck requires a valid license which is provided as hardware security key (dongle). USB and LPT dongles are available. Please note that a Premium license is required in order to integrate a plug-in check function into your check routine. If the check routine is completed once (including the plug-in functions) it can be run with any NeuroCheck license (except demo).

You obtain the standard NeuroCheck license when you purchase the software from your local NeuroCheck partner.

### 2. Protection of Plug-In

In addition to the standard NeuroCheck license, also a license for the NeuroCheck Plug-In is required. The protection of the plug-in is stored as a special flag in the same dongle as for the NeuroCheck license. If the plug-in cannot detect the special flag, the execution of the plug-in check functions in the automatic mode will always return NOK and the check functions in manual mode will periodically return NOK with a license error.

In order to get the license for the plug-in, please contact your local NeuroCheck partner. The license can be added to a standard NeuroCheck license by remote-programming of the dongle. The remote-programming works in the same way as a NeuroCheck update.

## Installation

### Installation

Copy the following files from the zip archive to the plug-in directory within the desired NeuroCheck project (e.g. 'C:\Users\Public\Documents\NeuroCheck\6.2\Default\Software Extensions\PlugIns').

- All files inside the `Binaries` directory
- All \*.chm files inside the `Documentation` directory

### Loading a Plug-In

In order to use a Plug-In, the Plug-In assembly must be loaded in NeuroCheck. The management of Plug-Ins takes place within the Software Settings dialog. The Software Settings dialog can be found in the System menu of NeuroCheck.

Please note that it is impossible to load or unload a Plug-In as long as a check routine is opened, that contains the Plug-In check functions. If the currently opened check routine contains Plug-In check functions, close the check routine first.

Within the Software Settings dialog please select the node Plug-Ins and the sub-node Plug-In in the tree to the left. The loaded Plug-In assemblies are shown in the list of Plug-Ins. Press the Add button to open a file selection dialog in order to select a further Plug-In assembly.

### Inserting a Plug-In check function to a check routine

A Plug-In check function is inserted using the Check Function Select dialog. All check functions of loaded Plug-Ins are listed in the Plug-In category of the Check Function Select dialog. Within the Plug-In category the check functions are ordered in sub-categories, where each sub-category represents the check functions of one Plug-In.

Beside the category the user will hardly notice any difference between the usage of Plug-In check functions and built-in check functions.

## Match Model Contour: Introduction

### Function overview

This function hierarchically searches for occurrences of previously defined **contour models** in an input image and creates new regions of interest with the objects detected. See [How to Use](#) for functionality details and [Check Routine Sample](#) for a quick start.

### Use case - Match Model Contour in contrast to Template Matching

The behaviour of the function is quite similar to the standard NeuroCheck check function **Template Matching**. Similarities to the standard check function are:

- The occurrences of the objects are detected and represented by regions of interests (ROI).
  - Only pre-known objects can be searched.
  - Non-contiguous objects (e.g. an "i" together with its dot or the typical characters created by needle stamping machines) can be searched.
- The objects that are searched are represented by models (templates). Therefore:
- For every occurrence the position, dimension and orientation is computed and represented as feature of the ROI.
- The minimum quality of the match is user defined and is represented as feature of the ROI as well.
- Several classes of objects can be searched.
- One class can be represented by one or more models (templates).
- The search can be performed for all occurrences or for a limited number of occurrences.

In contrast to **Template Matching** the Contour Matching does not identify the occurrences by grey value correlation but by geometric features of the object edges. This causes some differences, e.g.:

- Contour Matching has a greater tolerance to variations of lighting including reflections.
- Contour Matching is able to find overlapped objects.
- The position, dimension and orientation detected by Contour Matching is more precise, e.g. important in robot vision.

### Input data

This check function requires a image and a list of ROIs as input data objects.

### Output data

New list of ROIs, corresponding to the detected objects. And the input image displaying the results.

### Result view

See result [Visualizations](#).

### Properties

 Check function group Plug-In.

 The check function generates feature information. See section [Features](#) for a list of features computed by this check function.

 The check function generates class information which can be evaluated using check function **Evaluate Classes**. Classes are edited using the [Model Editor Dialog](#).

 The check function has a [Parameter Dialog](#).

 The check function has own result [Visualizations](#).

## Match Model Contour: How to Use

### Details of the procedure

- For the found models, new ROIs are created. These ROIs correspond to the bounding box of the found model.
- The group number of the generated ROIs corresponds to the group number of the Input-ROIs in which they are located.
- Each created ROI contains a number of **feature** values, e.g. its quality, scale factor or rotation angle, which can be used for data output or in succeeding check functions like **Screen ROIs**.
- The function generates the objects as new regions of interest which exhibit the highest degree of correspondence with one of the models. The maximum number of result objects can be set arbitrarily. The detected result objects will inherit the group number of the search ROI.
- The degree of similarity between object occurrence and taught model is determined from the fitting error between points of the model and points present in the image. The actual value that is used for comparing two points is not the grey value of both points, it is a value that contains information of the edge, the point belongs to. The **score** is given as quality of the occurrence.
- The function is able to find non-contiguous objects as a single region (e.g. an "i" together with its dot or the typical characters created by needle stamping machines).
- Depending on the chosen settings, the function is able to find rotated, scaled and partly overlapped objects while tolerating variations of the illumination.
- Disadvantages are the necessity for a-priori knowledge of the objects to be found and the amount of computation required.

### Pyramidal Search

A pyramidal search algorithm is implemented. First, a set of hierarchical levels of different resolutions of the input image and the model is generated. These data structures are then used top down to find the positions in the image which matches the given model.

For the actual search, the algorithm checks the top level, which is the level with the most rough resolution, first. The result positions are given down to the next finer level, where the search is only performed locally around the given positions. Step by step all resolution levels are checked in order to finally find the best match in the finest resolution level (bottom level).

The different resolution levels can be used to recognize and discard bad matches very fast and avoid unnecessary comparisons.

### Model Data Structure

Model data is saved separately from the check routine in a zip-file, which can be found in `\Check Routines\Templates` in the current project directory. The zip-file contains:

- XML file with the specified edge points (gradients) for each level.
- PNG of the model edges.



Model data is saved as zip-file into the project's Template directory, when the check routine is saved or exported as XML. So the parameters of this check function will be consistent with the geometric variations in the model XML. This takes effect as long as a model is not used and manipulated by several checks or in several check routines.



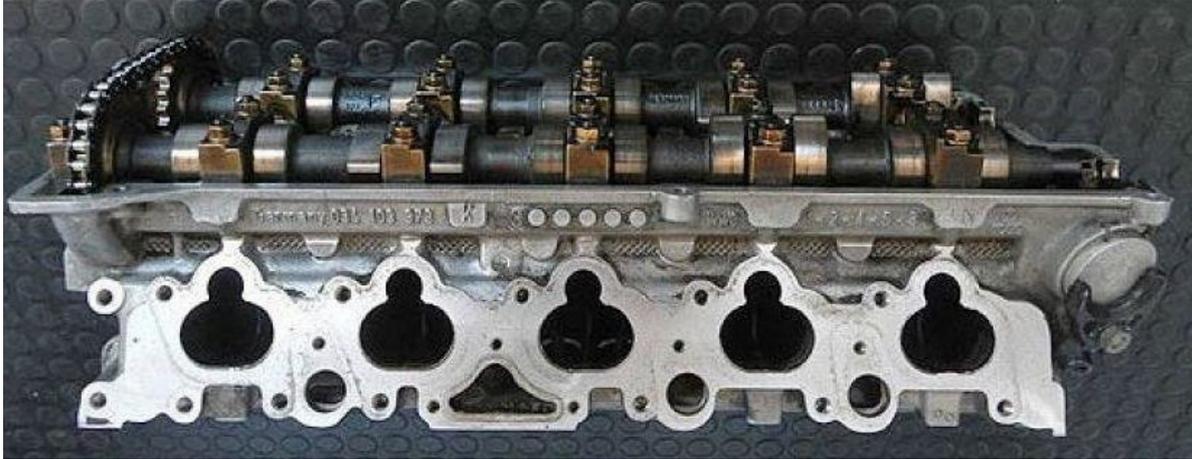
#### **This check function uses references to models.**

When **duplicating a check**, only the reference to the model used in Match Model Contour is duplicated, not the model file itself. Also when **importing a model**, you will only create a further reference to an existing model. This has the effect, that model manipulation in one check will have effect on all checks, that are using Match Model Contour with this model.

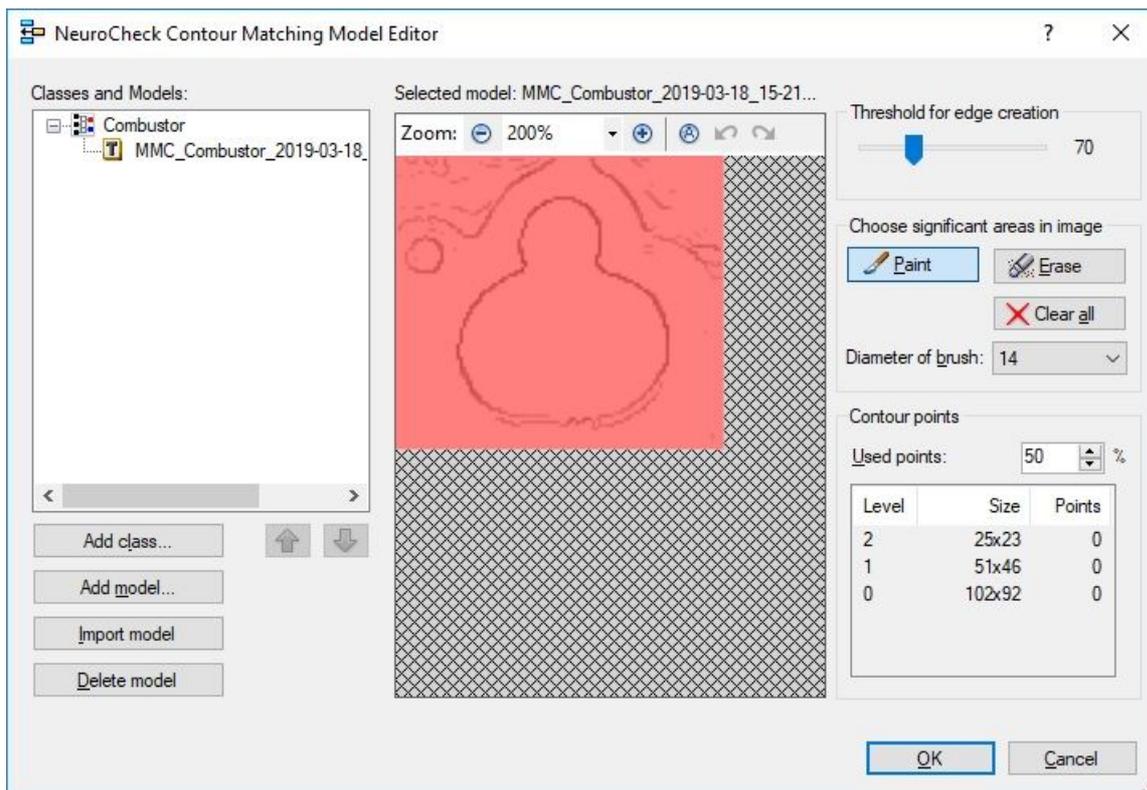
## Match Model Contour: Check Routine Sample

### Check routine sample

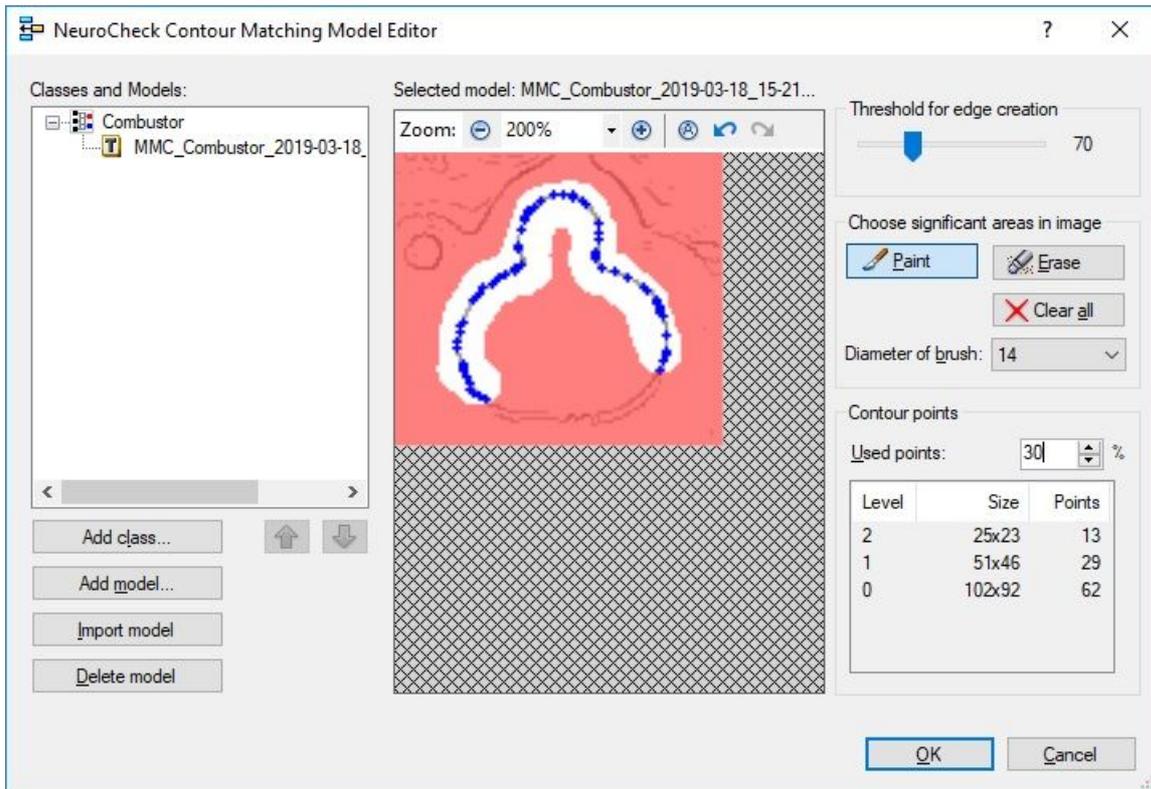
- As a sample the five combustors of a motor have to be detected in a color image.



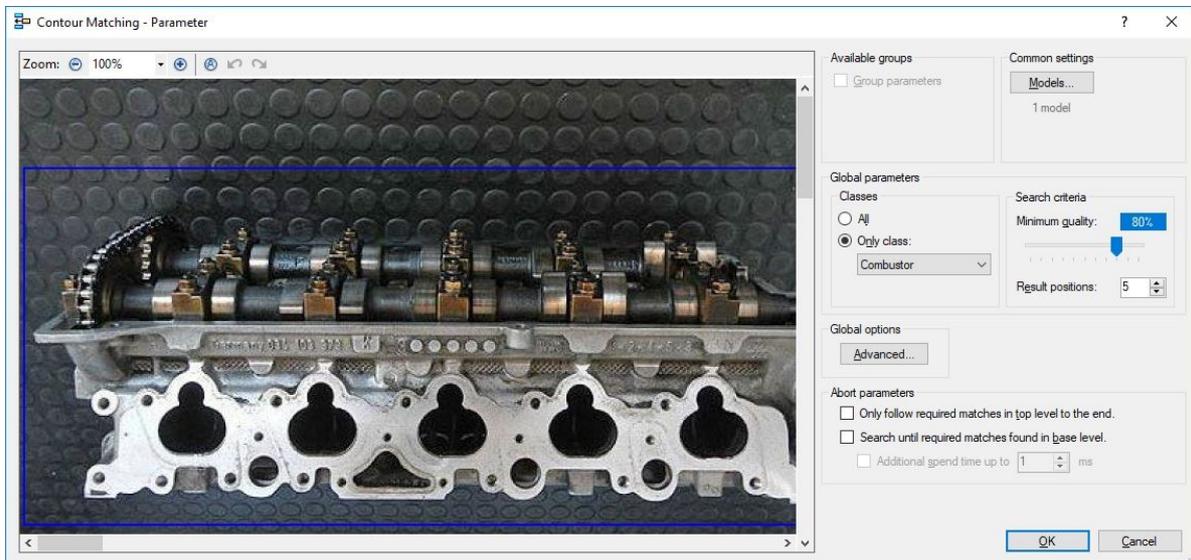
- At first you have to open the Model Editor Dialog to add at least one class and one model.



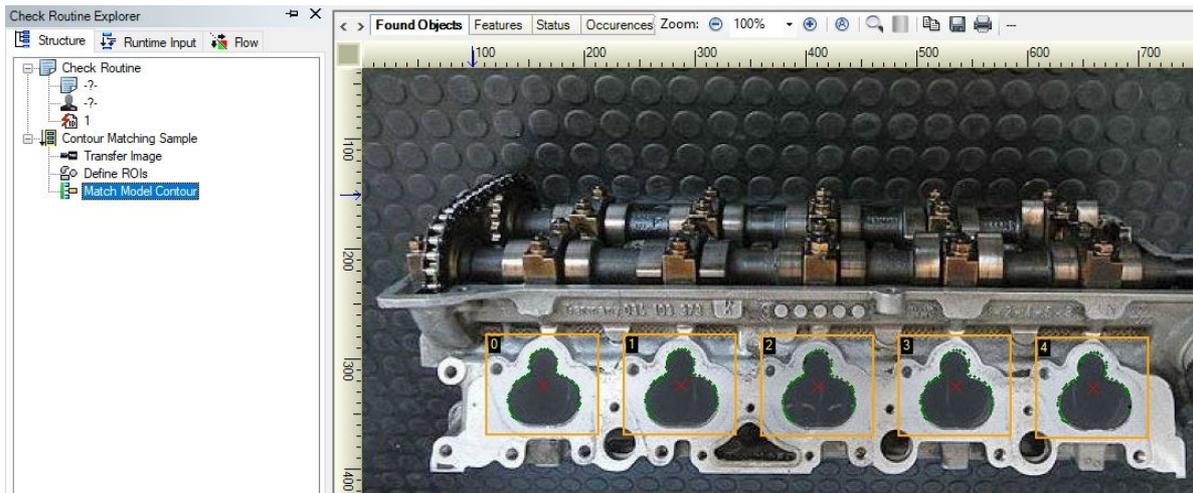
- Select "Care-areas" for the model.



- Set global parameters and global options in the Parameter Dialog. For this simple sample minimum quality and result positions have to be adjusted.



- Search result and overview of the Check Routine Sample.



## Match Model Contour: Parameter Dialog

### Screenshot of Parameter Dialog



This plug-in check function has a **Parameter** dialog. The **Parameter** dialog contains the following elements:

Element	Description
	Reduces the image area displayed.
<input type="text" value="800%"/>	The list shows pre-defined zoom factors. You can also enter values manually. After pressing Enter, the image area is enlarged/reduced by this value.
	Enlarges the image area displayed.
	Automatic zoom factor for a full image view on the dialog's entire display area.
Available Groups	The check box "Group parameters" can only be activated, if there are several input ROIs with different group numbers. It enables the configuration of the Contour Match algorithm for one group separately. Please activate therefor the check box "Group parameters" and select one group number in the appearing group number list. All parameter definitions which are made subsequently affect only ROIs of the selected group number. To define the parameters for the next group number, select the according group number in the group number list and set the configuration. If the check box "Group parameters" is not selected, the parameter configuration is the same for all groups.
Common Settings	The button "Models" opens the <a href="#">Model Editor dialog</a> for creating and editing models and classes.
Classes	If the radio button "All" is checked, all models from all classes are used for the search. If you have several classes and check the "Only class"-radio button, the drop down menu is enabled and you can select one specific class. Only models from the selected class will then be used for the search.

Element	Description
Search Criteria	<p><b>Minimum quality:</b></p> <p>Sets the acceptance level for the quality of the match. Detected objects with a quality below the threshold are discarded. The value to describe the quality of the match is a normalized value between 0 and 1. 0 means that the model does not fit at all. 1 means that the match is perfect.</p> <p><b>Result positions:</b></p> <p>Specifies the maximal number of objects the function will create inside the chosen search region. The number of objects in the output ROI list will not exceed this configured number. In case that more objects are found, only the best matching objects will be listed in the output ROI list. Please note also the Abort parameters to speed up the search.</p>
Global options	Opens the Options dialog for adjusting further settings of the search algorithm.
Abort parameters	<p>The three check boxes listed here can be used to accelerate the execution time of the search algorithm. To understand these parameters, it is necessary to know the pyramidal search concept of the algorithm in general (see Introduction).</p> <p><b>Only follow required matches from top level to the end:</b></p> <p>Only the best required matches in the level with the most rough resolution are further processed. They are ordered according to the quality value. This option influences the navigation through the finer levels and may lead to inaccuracy in the resulting matches.</p> <p><b>Search until required matches found in base level:</b></p> <p>Stops the search algorithm, when having found the specified number of result positions in the final level, that have a quality value higher than the defined minimum quality. This means there could be additional matches with a better quality, that will not be found. This parameter does not affect the navigation through the hierarchical data structure.</p> <p><b>Additional spend time up to:</b></p> <p>Can only be activated, when "Search until required matches found in base level" is activated. Having found the required matches in base level, a counter is started and the search algorithm will be continued until the specified time is reached.</p>

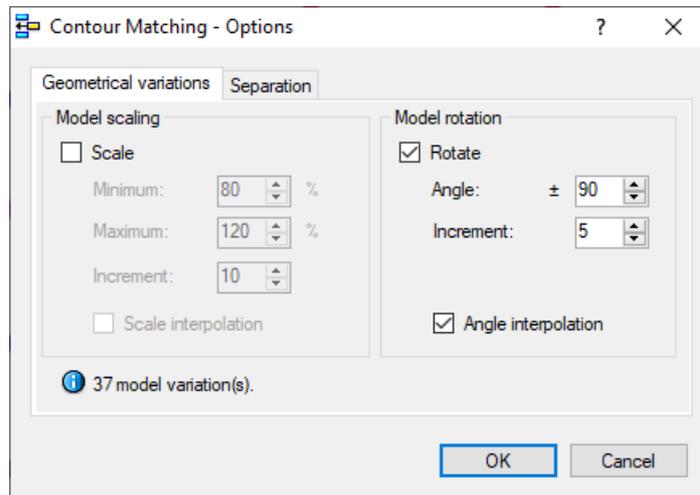
#### Plug-In global configuration file

There are additional hidden parameters for check function Match Model Contour in the plug-in configuration file NC62CFG.PI.CFGX of the current project configuration directory.

Element	Description
MatchModelContourShadowZoneKeepMaximaCount	Specifies the number of retained result positions in the shadow area (size of model occurrence) of a alpha match. If a larger number of <u>closely positioned</u> results are searched it can be helpful to increase that number. Of cause this has a negative effect on performance. Default value is 5.
MatchModelContourNumberResultsKeepInTopLevel	Specifies the number of result positions retained in top level. It can be helpful to increase this number when searching for models on a similarly textured surface. Or generally in the case of inspections with poor selectivity. Of cause this has a negative effect on performance. Default value is 3.

## Match Model Contour: Options Dialog (Geometrical variations & Separation)

☑ Screenshot of Options Dialog: Geometrical variations

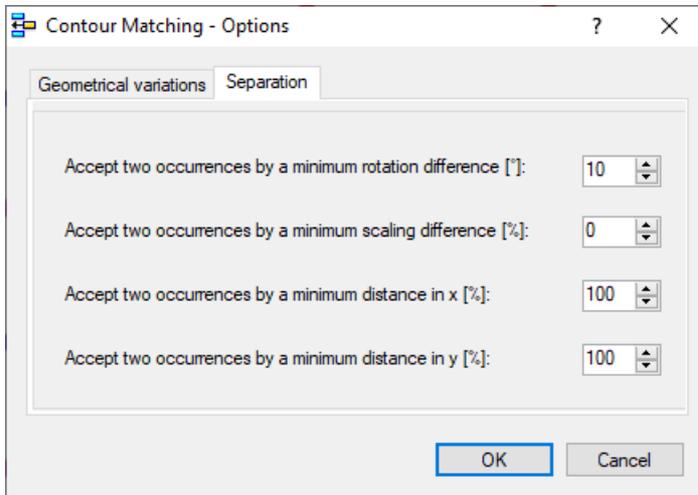


The tab **Geometrical variations** of the **Options** dialog contains the following elements:

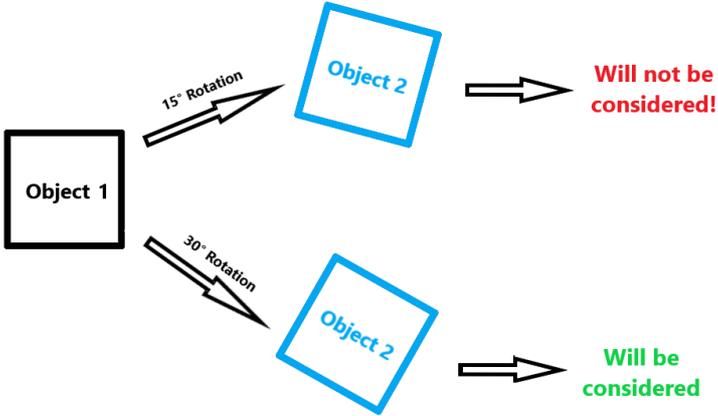
Element	Description
<b>Model scaling</b>	
Scale	If the checkbox "Scale" is activated the search is performed for model occurrences in the scale range between <b>Minimum</b> and <b>Maximum with the defined Increment</b> . Otherwise the search is performed for model occurrences with original size only. Example:
Minimum [%]	Specifies the minimum possible scale factor. The scale range reaches from 50% to 200%.
Maximum [%]	Specifies the maximum possible scale factor. The scale range reaches from 50% to 200%.
Increment	Specifies the step size of the scaling. The models will be scaled within the range from Minimum to Maximum with this increment. Occurrences of each scaled model are searched in the image.
Scale Interpolation	Iterates each final match between +/- scale increments and linearly interpolates the new best match in a +1 / -1 neighborhood.
<b>Model rotation</b>	

Element	Description
Rotate	<p>If activated, the search is performed for model occurrences in the angle range specified by <b>Angle with the defined Increment</b>. Otherwise the search is performed for not rotated model occurrences only.</p> <p>Example:</p> <div data-bbox="539 510 1209 750" style="text-align: center;"> <p>The diagram illustrates a 30-degree rotation. On the left is a black-outlined square labeled 'Template'. A white arrow with a black outline points to the right, with '30° Rotation' written above it. On the right is a blue-outlined square labeled 'Object', which is rotated 30 degrees clockwise from the original orientation of the template.</p> </div>
Angle	Specifies the positive and negative angle variation.
Increment	Specifies the step size of the angle. The models will be rotated within this range with this step size. Occurrences of each rotated model are searched in the image.
Angle Interpolation	Iterates each final match between +/- angle increments and linearly interpolates the new best match in a +1 / -1 neighborhood.

☑ Screenshot of Options Dialog: Separation



The tab **Separation** of the **Options** dialog contains the following elements:

Element	Description
Accept two occurrences by a minimum rotation difference	<p>The minimum rotation difference (in °) between two objects to be admitted.</p> <p><b>Example - Minimum 20° difference to be considered:</b></p> 
Accept two occurrences by a minimum scaling difference	The minimum scaling difference (in %) between two objects to be admitted.

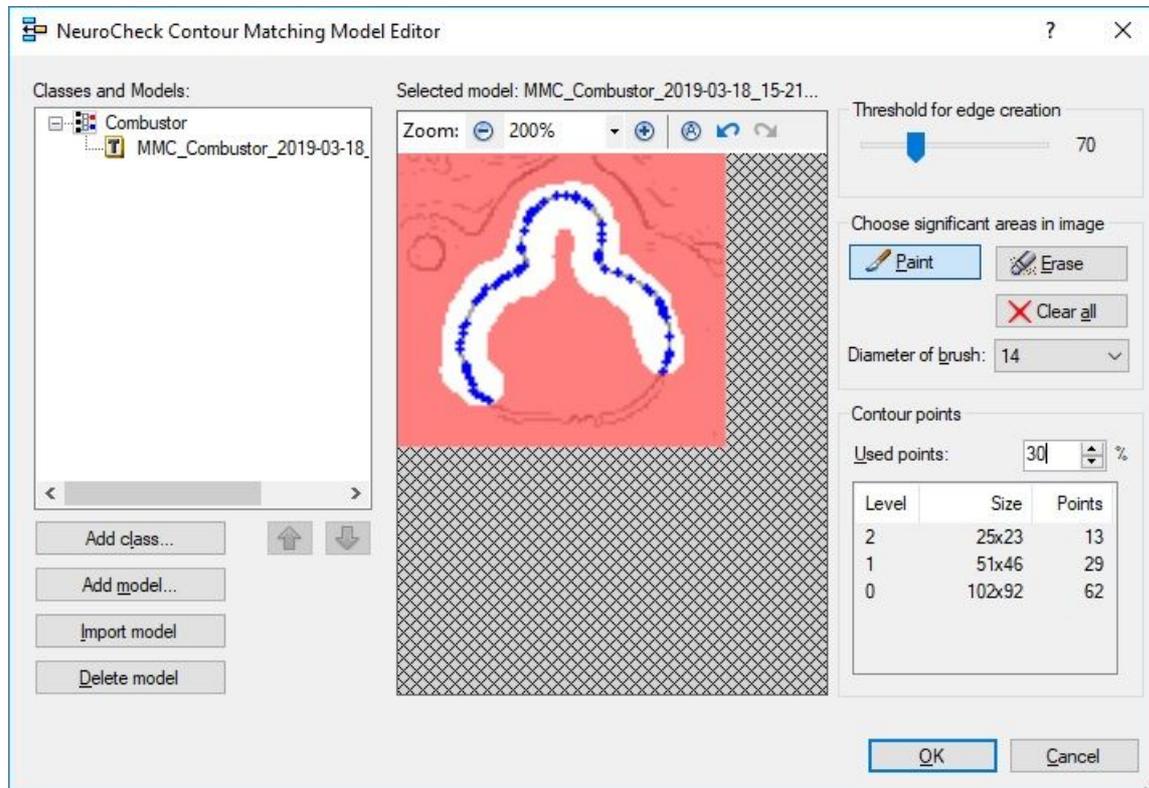
Element	Description
<p>Accept two occurrences by a minimum distance in x</p>	<p>The minimum distance in x-coordinate (in %) between two objects to be admitted. The percentage distance between the two objects is calculated based on their average width.</p> <p><b>Example - Minimum 50% distance to be considered:</b></p> <div style="text-align: center;">  <p>Object 1      Object 2</p> <p>Will not be considered!</p> </div> <div style="text-align: center; margin-top: 20px;">  <p>Object 1      Object 2</p> <p>Will be considered!</p> </div>
<p>Accept two occurrences by a minimum distance in y</p>	<p>The minimum distance in y-coordinate (in %) between two objects to be admitted.</p>



The separation parameters are applied in combination in such a way that if **one** of the acceptance parameters applies, the second model is accepted.

## Match Model Contour: Model Editor Dialog

☑ Screenshot of Model Editor Dialog



This plug-in check function has a **Model Editor** dialog for creating and editing models. The **Model Editor** dialog contains the following elements:

Element	Description
Classes and Models	<p>Structure:</p> <ul style="list-style-type: none"> <li> 1st level: Classes</li> <li> 2nd level: Models</li> </ul> <p>Handling:</p> <p>Organize the tree content with the buttons below.</p>
Add class...	<p>Opens the <a href="#">Add New Class</a> dialog to add a new class to the model set.</p> <p>Model sets should not contain empty classes, so you should not specify classes for which there are no patterns available on your training images. You can add and delete classes later as well. A model has to belong to a class, so there is one class needed at least.</p>
Add model...	<p>Opens the Create Models dialog to create new models.</p>
Import model	<p>Imports existing model using windows standard dialog. To import a model means that a new reference to an existing model file is created.</p>

Element	Description
Delete	<p>Deletes the selected element:</p> <p>Classes: This button will delete the currently selected class from the model set. Note that this will also delete all model references belonging to this class.</p>
	Models: Deletes the currently selected model reference.
	Moves the selected model in the next upper or lower class respectively.
	Reduces the image area displayed.
<input data-bbox="215 672 335 705" type="text" value="800%"/>	The list shows pre-defined zoom factors. You can also enter values manually. After pressing Enter, the image area is enlarged/reduced by this value.
	Enlarges the image area displayed.
	Automatic zoom factor for a full image view on the dialog's entire display area.
	Undo and Redo respectively the last change of the "Care-areas".
Image panel	Shows the selected model with the defined "Care-areas" that will be searched in the image.
	These are the white areas in the image panel. Only the points that occur within the these areas are used for the search for model occurrences. The definition of the areas can be set in this image panel only. Areas that are marked in red will not be considered in the search.
Threshold for edge creation	With the help of this slider you can define which edges should be used to create the model. The value can be set between 0 and 255 according to the contrast of the edges. 0 means that edges with a very small contrast are used, 255 means that edges with a very high contrast are used, respectively. This parameter is used as a preselection: only edges with a higher contrast than the here defined values are visualized in the image panel and can be selected via the paint function.
 Paint	Select the tool for painting the "Care-areas" in the image by moving the mouse with holding the left mouse button.
 Erase	Select the tool for erasing "Care-areas" areas in the image by moving the mouse with holding the left mouse button.
 Clear all	Deletes all defined "Care-areas".
Diameter of brush	Specifies the diameter of the tool for painting and erasing "Care-areas" respectively.
Used Points	Specifies the percentage of points that are used for the search process. The value can be set between 0 and 100. If set to 100 all preselected points will be used. If set to 50 for example, only every second point will be used for the search.
Grid View	The algorithm creates a hierarchical structure for each model. The size of the model and the number of points in each level are shown in this grid view. The number of points has a big influence on the execution time of the Check Function Match Model Contour. The more points are used to for the search of the model in the image, the more time consuming is the execution.
	To keep the execution time low, we recommend to set the percentage of used points to a value which ensures that the number of points in the highest level is approximately 10.



Model data is saved as zip-file into the project's Template directory, when the check routine is saved or exported as XML. So the parameters of this check function will be consistent with the geometric variations in the model XML. This takes effect as long as a model is not used and manipulated by several checks or in several check routines.



When **duplicating a check**, only the reference to the model used in Match Model Contour is duplicated, not the model file itself. Also when **importing a model**, you will only create a further reference to an existing model. This has the effect, that model manipulation in one check will have effect on all checks, that are using Match Model Contour with this model. When **importing a model**, check the geometric variations in the model XML file and adopt them within the Options Dialog if necessary. As geometric variations are global options, they will not be updated in the Options Dialog after model import.

## Match Model Contour: Add New Class Dialog

☑ Screenshot of Add New Class Dialog

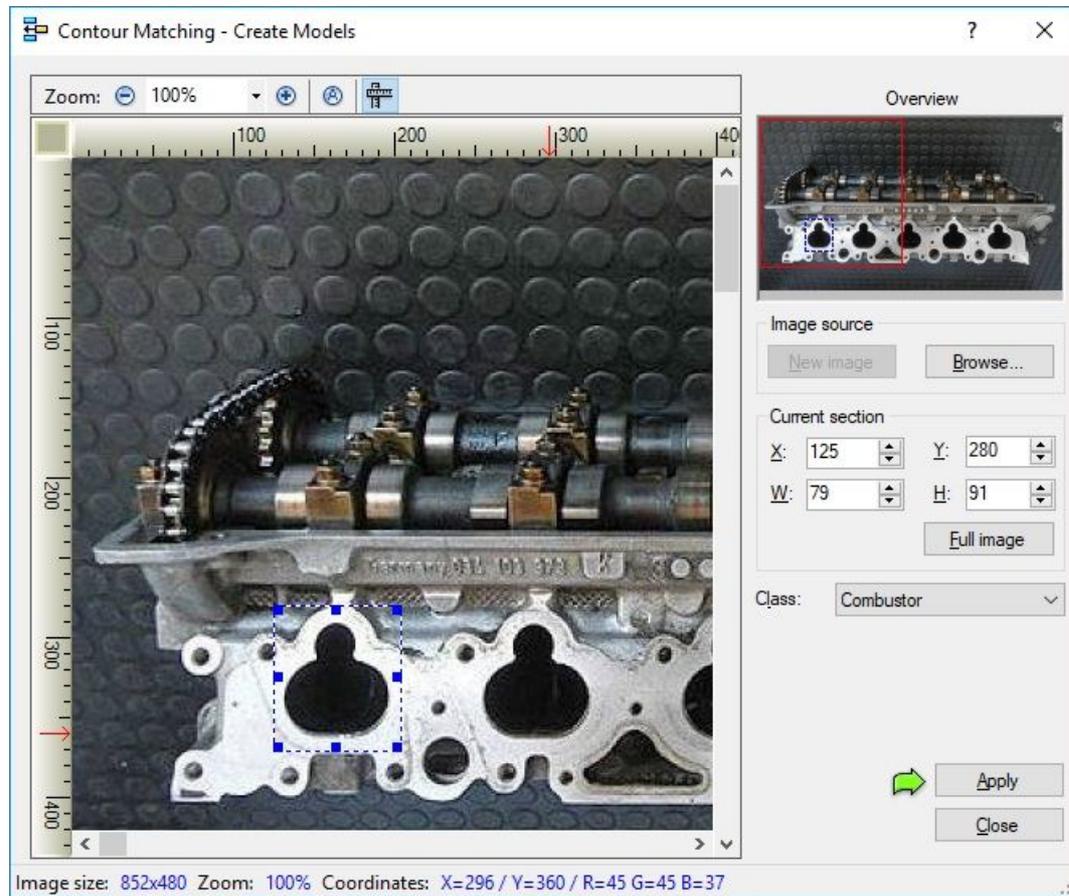


This plug-in check function has an **Add New Class** dialog for creating new classes. The **Add New Class** dialog contains the following element:

Element	Description
Class name	Specifies the name for a new class to be added to the list of available classes.

## Match Model Contour: Create Models Dialog

▣ Screenshot of Create Models Dialog



This plug-in check function has a **Create Models** dialog for creating new models. The **Create Models** dialog contains the following elements:

Element	Description
	Reduces the image area displayed.
	The list shows pre-defined zoom factors. You can also enter values manually. After pressing Enter, the image area is enlarged/reduced by this value.
	Enlarges the image area displayed.
	Automatic zoom factor for a full image view on the dialog's entire display area.
	Shows or hides a horizontal and a vertical ruler on the edge of the view field.
Image panel	Displays the current image to define the model area.
	This rectangle specifies the model area. To position and resize the rectangle you can drag and drop it or edit the values within the group box "Current section" The positioning can also be done by a right mouse button click to a specific position in the image panel. The center of the rectangle will then be moved the new position.
Overview	Displays a small full-image to give you an overview of the model position (blue-white frame) particularly on large or enlarged images.
	On enlarged images, the red frame is corresponding to the current image area displayed on image panel. Moving the red frame via mouse will update the image area in the image panel automatically.
New image	Executes the check in the background. When getting the images from camera (or if multiple bitmap files in check function <b>Transfer Image</b> are selected) you will receive an updated image in the image panel. This allows you to quickly collect a set of models from different test pieces without leaving this dialog.
Browse...	Imports other image files to define models, when working without any connected cameras.
Current section: X / Y	Changes the model position via X and Y coordinates using the upper left edge point.
Current section: W / H	Changes the size of model area for width (W) and height (H).
Full image	Selects the entire image as model area.
Class	Select the class of the model from this list. A model must belong to a class. If you need a new class for the new model, select <b>Close</b> to add a new class in Model editor.
Save	This button adds the selected rectangular area as a new model and assigns a reference to this model to the class currently selected in the <b>Class</b> drop down list. A model is saved as zip-file into the project's Template directory, when the check routine is saved or exported as XML.
Close	To exit the dialog.

## Match Model Contour: Features (Classification result)

This section describes the features computed by the check function Match Model Contour. The features can be used by functions like **Sort ROIs**, **Screen ROIs** and **Classify ROIs**.

The following features are computed and added to the features of every region of interest found by this function:

Element	Description
Class	Index of the class the model belongs to, which exhibits the greatest similarity to the occurrence.
Quality of classification	The quality of matching points with edge information between detected occurrence and model. The value is normalized to a value between 0.0 and 1.0. A value of 1.0 indicates that the model has a perfect fit.
X-Position	X coordinate of the occurrence. The center point of the bounding box is used as reference.
Y-Position	Y coordinate of the occurrence. The center point of the bounding box is used as reference.
Angle	The angle in degrees of the occurrence relative to the reference angle specified for the model.
Scale	The factor the model is scaled to get the same size as the occurrence. 1.0 means that the found occurrence has the same scale as the model.
Model Index	Model number within one class. The first model gets the index 0, the second 1 and so on. Helps to assign the found object to a defined model, in order to be able to optimize a special model.

## Match Model Contour: Visualization

This section describes the result visualizations the check function Match Model Contour provides.

Element	Description
Found Objects	Displays the model edges and the created ROIs of the found occurrences within the input image.
Features	Displays the computed features of the found occurrences: <ul style="list-style-type: none"> <li>- Rotation angle</li> <li>- Class</li> <li>- Quality of classification</li> <li>- X-Position</li> <li>-Y-Position</li> <li>- Scale</li> <li>- Model index</li> </ul> See <a href="#">Features</a> for more information.
Status	Gives further information about how many objects are found for each model in top level and about the maximum quality value. Also the best match position in top level overall models is listed.

## FAQ

### Contour Matching does not detect any object

- Please make sure that the search area is large enough or choose the complete image as search area
- Decrease the limits for the required minimum quality (score) and target score
- Activate search for scaled or rotated objects

### Contour Matching is too slow

- If you know the number of objects to be expected in the image, only search for the specified number instead of for all objects.
- Restrict the search area in the image if possible.
- Limit the search for scaled and rotated objects if possible.
- Decrease the number of models if possible. There is no use to teach a model twice, or to teach a very similar model. It is better to teach an ideal model once than a number of variations (which is the opposite to **Classify ROIs**).
- Decrease the number of used points for each Model in the Model Editor.
- Use the two speed-parameter in the Match Model Contour parameter dialog. For detailed description of these parameter, please see the section Parameter Dialog.

## Support Services

For technical support, please contact your local NeuroCheck partner or NeuroCheck GmbH:

Phone: +49 (0) 7146 - 89 56-40

E-Mail: [support@neurocheck.com](mailto:support@neurocheck.com)

Web: [www.neurocheck.com](http://www.neurocheck.com)

Before contacting us, please provide some important information about your system:

Information about your NeuroCheck installation and your PC setup:

- Use the NeuroCheck Diagnostics tool to check your installation and computer configuration.
- The NeuroCheck Diagnostics is installed in the "Tools" folder within your NeuroCheck installation.

Log file information:

- Logging for NeuroCheck can be activated in **System > Software Settings > Diagnosis > Logging**.

