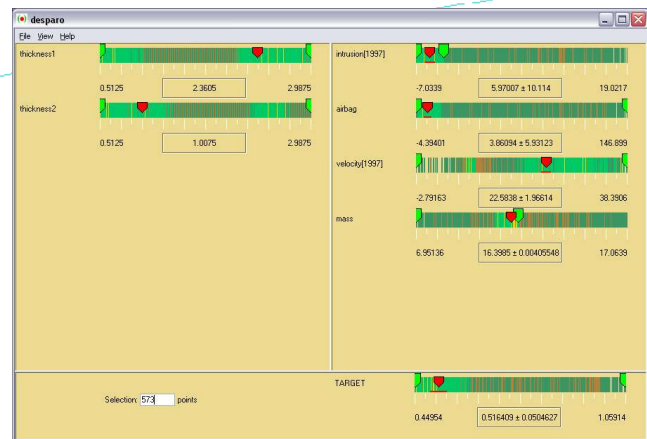
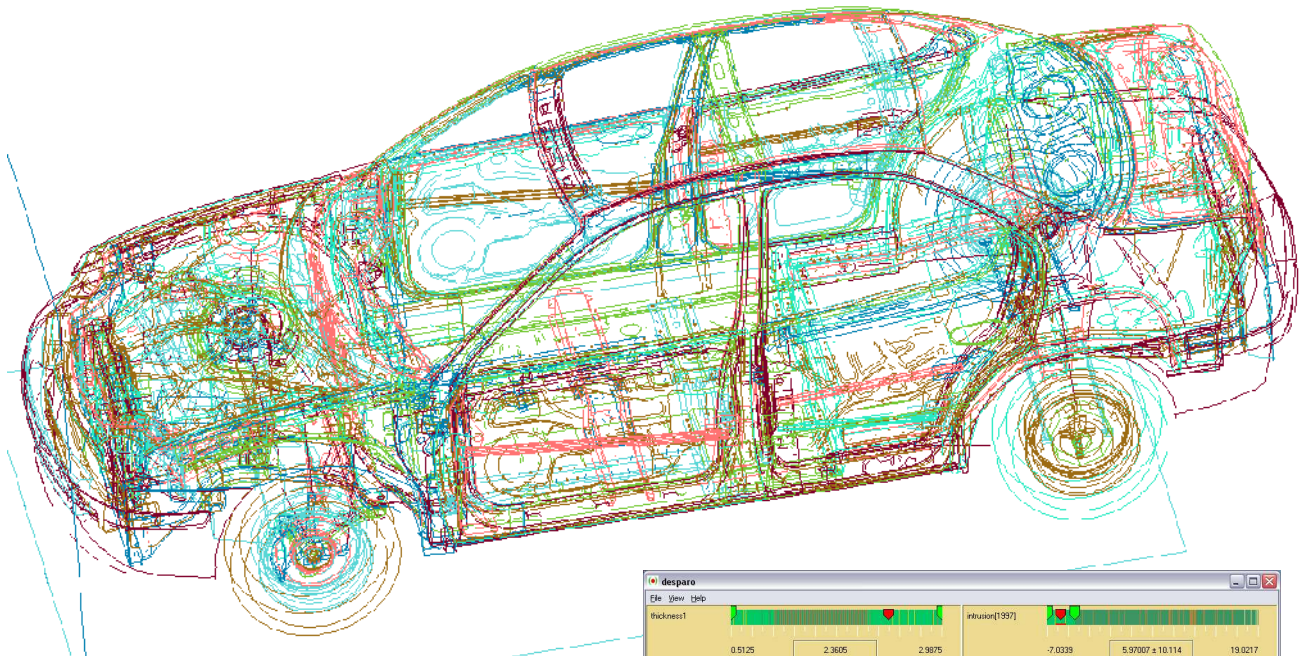


DesParO V1.0

Interactive Environment for
Design Parameters Optimization



Fraunhofer Institut
Algorithmen und Wissen-
schaftliches Rechnen

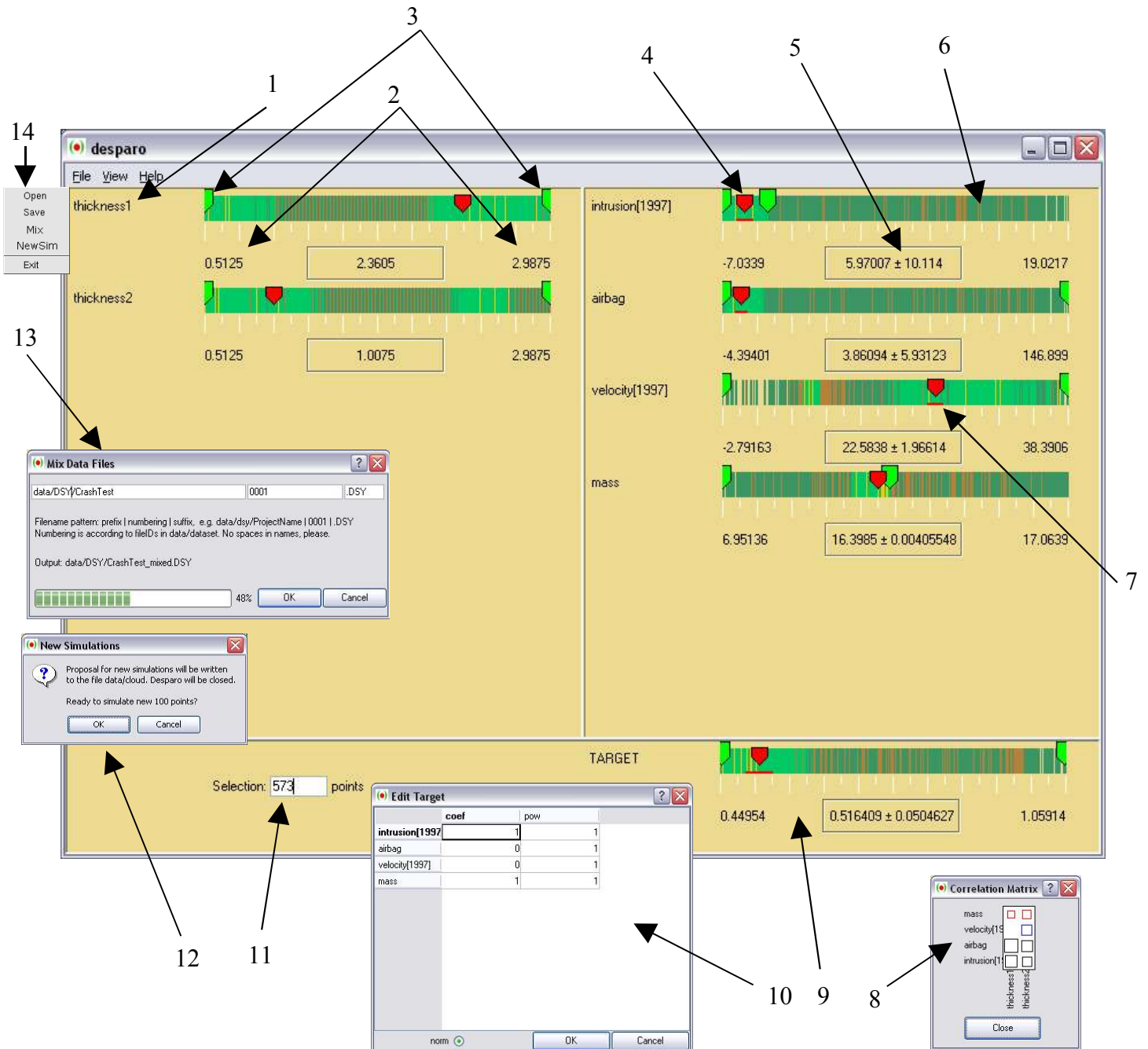
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DesParO V1.0

Interactive Environment for Design Parameters Optimization

This package performs non-linear multidimensional interpolation of discrete user specified dataset to provide interactive exploration of the underlying solution space.

Method: RBF - Radial Basis Functions enforced by real-time robust tolerance estimator.



Usage of Desparo Graphical User Interface

On the left hand side the explorative fields for parameters are located.
On the right hand side the explorative fields for criteria are located.

The following features are available.

1. every field includes the name of corresponding parameter / criterion.
2. the lowest and the highest values for this parameter / criterion.
3. two green sliders, which could be moved between the minimum and maximum and allow to select new lower and upper bounds.
4. the red slider, which on parameter exploratory field could be moved between green sliders and allows to specify current value of this parameter. On criterion exploratory field red slider only shows the current value of corresponding criterion, and could not be moved.
5. the output box with the current value of the parameter / criterion. For criterion value also tolerance limits are displayed.
6. the textured strip under the sliders, which represents projection of the dataset onto the parameter axis, every point of the dataset is shown by a vertical line, orange lines correspond to the simulation results, green lines correspond to the interpolated points, dark orange and dark green lines correspond to the points out of selection by lower and upper bounds (green sliders).
7. tolerance limits for criterion value.
8. menu item View Matrix shows correlation matrix of the metamodel indicating most influencing design variables and most sensitive optimization criteria (details see below).
9. exploratory field for Target function is located at the bottom right.
10. menu item View Target allows to specify the Target function for multicriterial optimization. Every criterion there has two input boxes, where coefficient and power for this criterion could be specified. These values are used for construction of Target function in the following two forms:

unnormalized (norm=0): $TF = \sum C_i |Crit_i|^{p_i}$

normalized (norm=1): $TF = \sum C_i |(Crit_i - \min(Crit_i)) / (\max(Crit_i) - \min(Crit_i))|^{p_i}$

where C_i is coefficient, p_i is power, $Crit_i$ is value of i-th criterion and the sum is computed over all criteria. "norm" flag is defined by radiobutton.

11. selection field at the bottom left shows the number of points currently selected by green sliders. Only green points are counted here. The user can enter a smaller number in this field to reduce the selection set.
12. menu item File NewSim writes down currently selected points to a file data/cloud. The file format is compatible with LMS Optimus input table. The points can be used then to generate new simulations (details see below).

13. menu item File Mix performs the interpolation of FEM files (e.g. .DSY files) to the point specified by red sliders on parameter axes (details see below).

14. menu item File Save allows to save current state of the application to .res file in the format

```
name-of-par1      min center max  0 0 0
name-of-par2      min center max  0 0 0
....
name-of-par-last  min center max  0 0 0
name-of-crit1     min center max  tol coef pow
....
name-of-crit-last min center max  tol coef pow
TARGET           min center max  tol norm 0
```

Here min, center, max are corresponding positions of the sliders, tol is tolerance for criteria values, coef and pow are coefficients and powers used in the construction of target function, norm is the target function normalization flag.

Menu item File Open loads this file.

Menu item File Exit closes the application.

Desparo HowTo

... find the minimum of target function or single criterion:

- move corresponding right green slider on the explorative field to the left
- on the parameter fields regions appear, where the interpolated/simulated solutions are still available
- move every red slider of parameters to the middle of corresponding region
- adjust every red slider of parameters inside the region and achieve the exact minimal value of the target function or single criterion.

... select Pareto front:

- move the right green slider of the first criterion to the left
- when the points on the texture of the second criterion begin to disappear from the left side, this is Pareto front
- move the right green slider of the second criterion to the left to see the same effect for the first criterion
- moving green sliders of both criteria, select region of interest on Pareto front.

... perform constrained optimization:

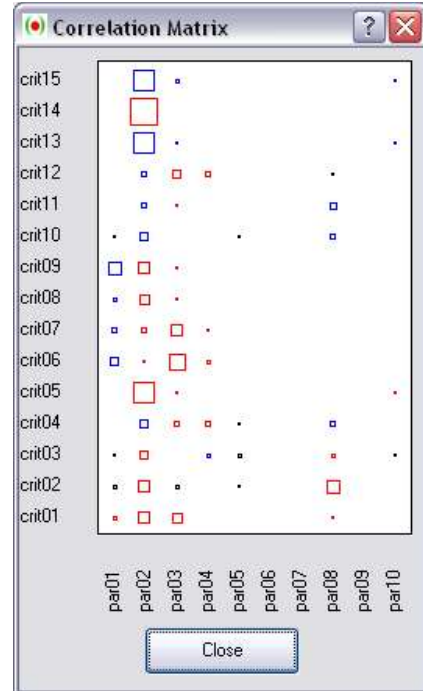
- move the green sliders on criteria fields to the required constraint range
- move the red sliders on parameter fields towards available green regions
- adjust the red sliders on parameter fields and achieve the optimal value of the target function or single criterion keeping all constraints satisfied
- ensure that criteria values together with tolerance limits are located completely inside constraint ranges, for safety of constrained optimization.

... use Target function:

- select menu item View Target
- specify coefficients, powers and normalization flag according to the formula above
- perform optimization of Target function using the bottom right exploratory field.

... understand Correlation matrix:

- select menu item View Matrix
- parameters are listed horizontally, criteria are listed vertically
- the size of squares shows the magnitude of parameter – criterion dependence, no square corresponds to negligible dependence
- the color of squares shows the direction of dependence: red if criterion increases with the increase of the parameter, blue if criterion decreases with the increase of the parameter, black if the dependence is not monotonous.



... mix FEM data files:

- select menu item File Mix
- specify filename pattern, e.g. data/DSY/CrashTest | 0001 | .DSY to mix the files CrashTest0001.DSY CrashTest0002.DSY CrashTest0003.DSY etc placed in directory data/DSY. Numeration of files is according to experiment IDs given in input dataset (see below)
- press Mix button
- the result stored in data/DSY/CrashTest_mixed.DSY can be displayed by available viewer.

Mixer accepts the following formats:

- PamCrash (.DSY)
- SimReal (.simr)
- VRML2.0 (.wrl)

Creation of new metamodel

Format of input dataset is the following ASCII table:

```
(list of parameter names) (list of criteria names)
exp.ID (list of parameter values) (list of criteria values)
exp.ID (list of parameter values) (list of criteria values)
.....
exp.ID (list of parameter values) (list of criteria values)
```

E.g.

```
thickness1 thickness2 intrusion[1997] airbag velocity[1997] mass
1 0.5625 1.1625 152.747 125.582 20.5316 10.021
2 0.5875 1.0125 160.945 129.466 21.5957 9.43074
.....
101 0.6125 0.8375 169.457 131.788 26.7844 8.72964
```

Note: the entries in the table are separated by spaces. The names of parameters and criteria should not contain spaces themselves. Experiment IDs are used for file identification during FEM file interpolation. The format is compatible with LMS Optimus ASCII summary export.

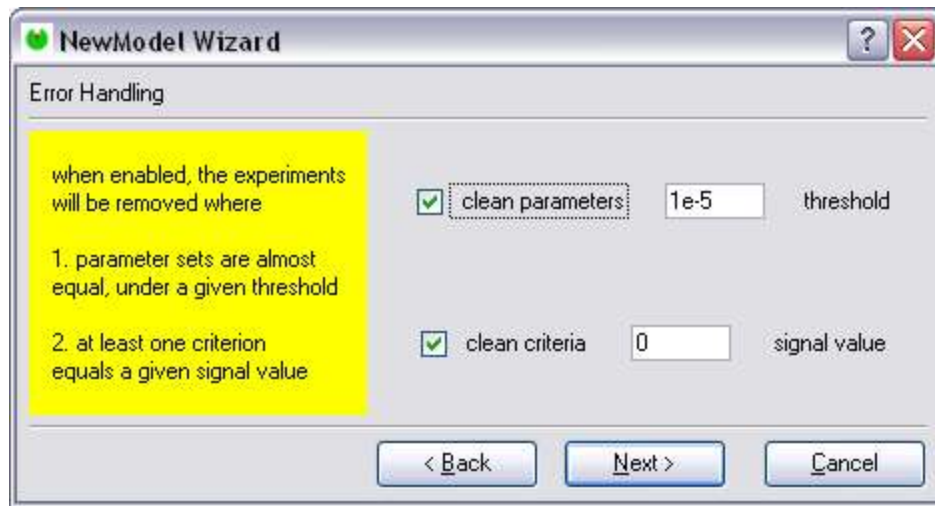
To create new metamodel from user specified dataset invoke *newmodel* wizard:



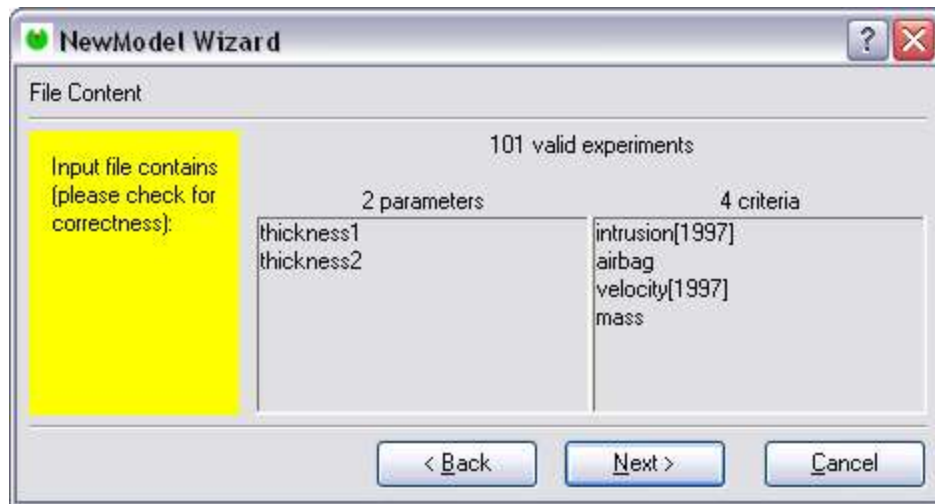
After specification of input dataset and the number of parameters and criteria the wizard performs preselection of experiments according to the following rules:

1. experiments with almost identical parameter sets are removed. User can specify threshold of parameters coincidence. This step is necessary to ensure well-posedness of the interpolation matrix.
2. experiments are removed where at least one criterion equals user-specified signal value. This step cleans up the failures of simulation program, corresponding e.g. zero instead of valid

positive value of criterion.

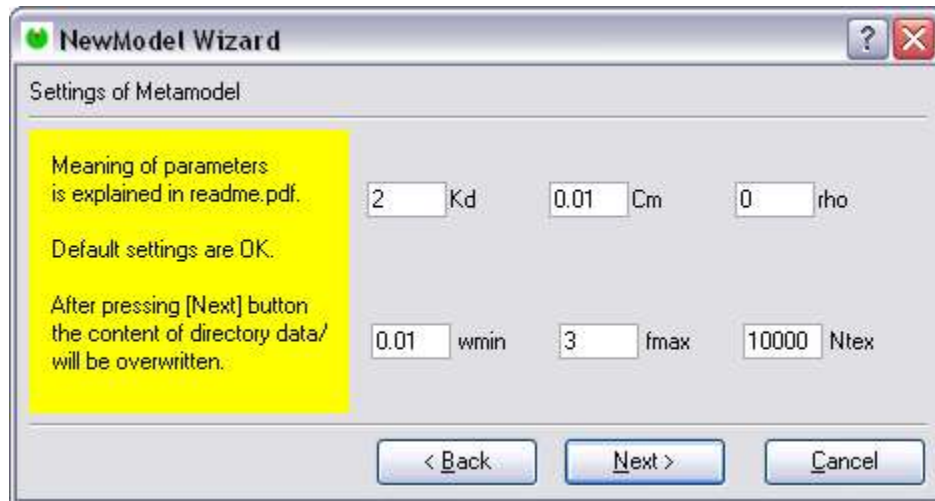


Then the number of preselected experiments and the names of parameters and criteria are displayed for user verification:



The following internal parameters are used to configure the metamodel:

- Kd - order of polynomial detrending (-1 no detrending)
- Cm - RBF constant (e.g. 0.01)
- rho - noise smoothing factor (0 no smoothing)
- wmin - minimal weight threshold (e.g. 0.01)
- fmax - maximal number of files threshold (0 no file interpolation)
- ntex - texture fill number (default 10000)



To improve precision of interpolation in the case if some functions in the dataset have constant, linear or higher order polynomial behavior the algorithm of polynomial detrending is used. Kd is the order of the corresponding polynomial. E.g to detrend constant, linear or quadratic function, Kd should be set correspondingly to 0, 1, 2; while to disable detrending set Kd=-1.

Cm is a constant, influencing the smoothness of RBF functions. For dimensions Npar=1...100, Ndata=100...1000 the value Cm=0.01 is optimal.

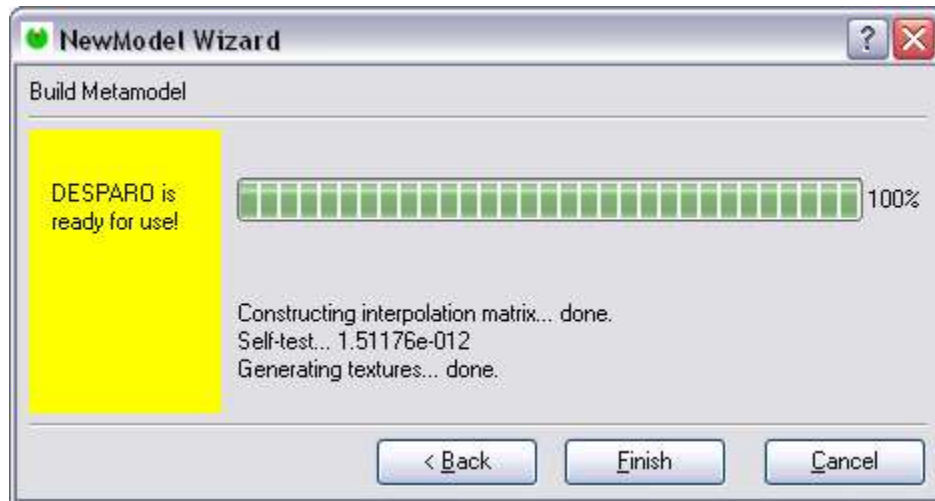
rho is the parameter for control of noise smoothening. If the data contain noise exact interpolation passing through the datapoints does not have sense. In this case set rho to positive value e.g rho=0.1, and RBF will smoothly approximate the dataset. Otherwise if the exact interpolation should be used, set rho=0.

wmin and fmax are internal parameters for interpolation of the files. Generally RBF produces non-zero weights for all files, however, many of them are close to zero. In this case the interpolation for all files will be the waste of time. To optimize this process, the following strategy is used. fmax datapoints closest to current parameters configuration are selected. All weights at these points, smaller by absolute value then wmin, are set to zero. The selected weights are normalized to have the unit sum and they are finally used to interpolate the files. Therefore, small wmin and fmax correspond to more fast interpolation, while large wmin and fmax correspond to more precise interpolation of the FEM files.

The parameters wmin and fmax are used only for interpolation of the files, where the interpolation process is time-consuming due to the large amount of data contained in the files. The values of criteria shown by GUI require less number of interpolations and are evaluated using all weights. To switch off file interpolation set fmax=0.

nttx – the number of interpolated points used to populate the textures.

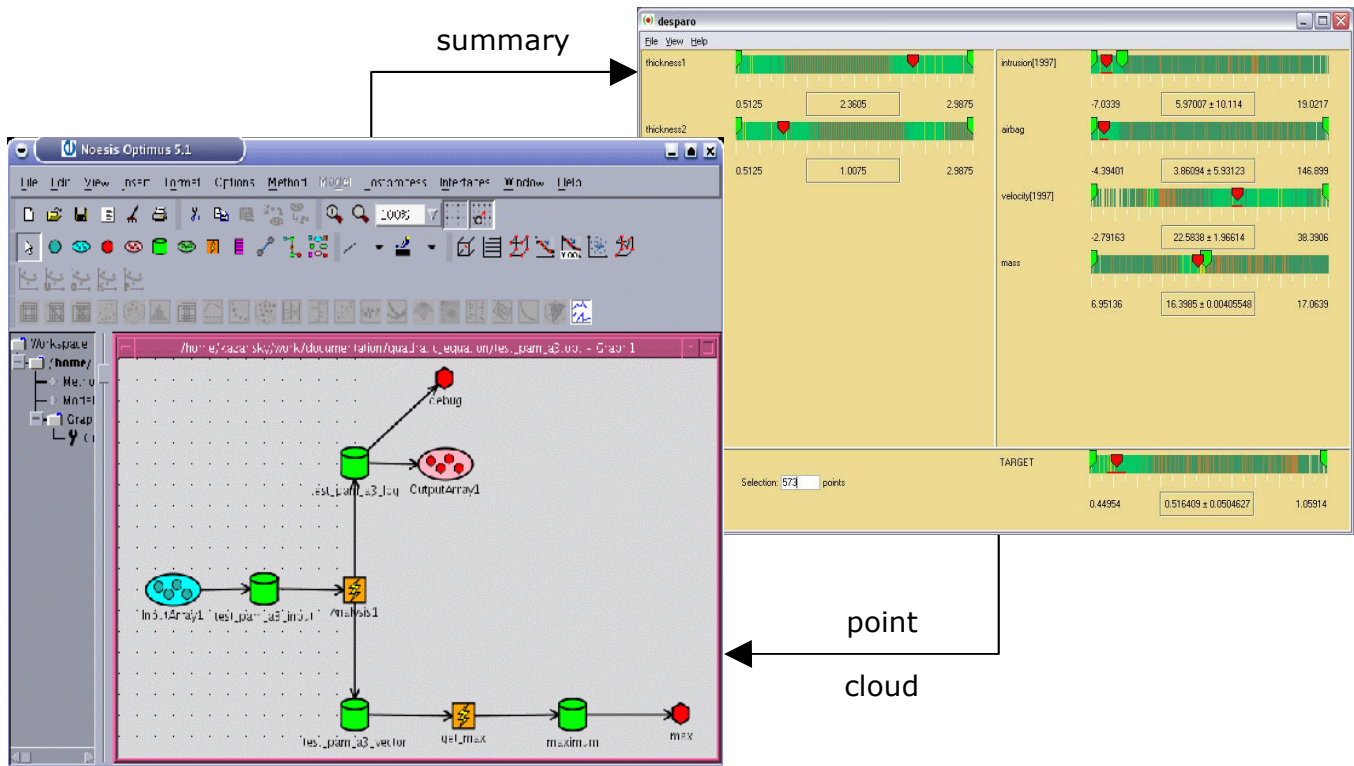
Newmodel wizard automatically selects the optimal values of metamodel internal parameters. After this step the metamodel located in data directory will be overwritten. Old metamodel can be preserved for further use by a backup of data directory before proceeding.



Finally newmodel wizard builds the metamodel and performs the necessary self-test. The value returned by self-test should be small, typically in the range $1e-14$... $1e-10$. Large self-test value indicates that the dataset contains almost coincident points, which should be removed at the earlier stage of metamodel construction (see above).

After successful construction of the metamodel Desparo GUI can be invoked for interactive optimization.

Desparo-Optimus interface



Desparo features the interface to LMS Optimus, enhancing the interactive optimization strategy of Desparo by workflow controlling capabilities of Optimus. The implementation is based on export of 'summary' files from Optimus and their import to Desparo, and export of files 'point' and 'cloud' from Desparo and their import to Optimus.

Typical optimization proceeds through the following stages.

1. generation of initial dataset, using *DOE Latin-Hypercube* method of Optimus. Start Optimus. Load your project file (*.opt), using File/Open menu of Optimus. Goto: Method/DOE/ Latin-Hypercube , set up Low/High limits and Apply.
2. Export the results summary as ASCII table: right click on the table item in the graph, select Load Results, Postprocess/Summary/Export/ASCII(*.txt).
3. Start Newmodel Wizard of Desparo loading the table as input dataset. Proceed as described in section 'Creation of new metamodel'.
4. Start graphical user interface of Desparo. Perform interactive optimization as described in section 'Desparo HowTo'.
5. Save the result using File Save menu of Desparo. In addition to *.res file Desparo saves optimal parameter values to an auxiliary file data/point readable by Optimus.

6. Import the file data/point to Optimus using menu item Method/Table/Load. Press Apply button. New simulation will be generated in the proposed point. If the result of simulation is satisfactory, optimization stops at this step.

7. Otherwise: in Desparo narrow limits on parameter and criteria axes to localize the region for new simulations. Reduce the number of points in Selection field if necessary. Create proposal for new simulations using File NewSim menu item. The parameter values for new simulations will be stored in the file data/cloud in a format of Optimus table, and Desparo GUI will be closed.

8. Import the file data/cloud to Optimus using menu item Method/Table/Load. Press Apply button. New simulations will be generated in the proposed points. Then proceed to step 2.

Optimization loop (2-8) is repeated until the necessary precision will be achieved.

Content of the package:

binaries (Windows):

desparo.exe - graphical user interface
newmodel.exe - newmodel wizard
qt-mt323.dll - QT runtime library
msvcr71.dll, msvcp71.dll - MS Visual C/C++ runtime libraries

binaries (Linux):

desparo - graphical user interface
newmodel - newmodel wizard
libqt-mt.so* - QT runtime library

flexlm license file:

desparo.lic

sample input file (courtesy of Audi):

data/pillarb.txt

derived auxiliary files:

data/names
data/model
data/matrix
data/texture
data/pattern
data/datamin

output files:

data/*.res - results of optimization
data/point - parameter values for the optimal point
data/cloud - proposal for new simulations

Installation:

copy all files from the installation media to *installation-directory*

Run the applications:

Windows:

double click on *desparo* or *newmodel* icons

Linux:

```
cd installation-directory  
./desparo  
./newmodel
```

See also: www.scai.fraunhofer.de/desparo.html