

PERSALYS, the graphical interface of OpenTURNS

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Contents

Overview

What's new?

What's next?

Bring Uncertainty Methodology to Engineers

- ▶ Partnership started in 2015
 - ▶ EDF R&D wanted to maximize the use of OpenTURNS® by its engineer/researcher (and improve an existing GUI) → develop a GUI to make more easy to use
 - ▶ Phimeca had already developed an "OpenTURNS GUI" (PhimecaSoft®) which satisfies some needs of EDF R&D but not all.
 - ▶ EDF R&D and Phimeca decided to start a specific partnership in order to develop a new GUI based on OpenTURNS® and "Salome Tools": Paraview, Yacs, ...

Some expectations regarding the GUI

- ▶ As easy to use as possible and, when it is possible, a GUI which can guide the user
- ▶ Possibility to use it inside Salome Platform to
 - ▶ Use super-computing resources (e.g. Gaïa, 3 052 Tflops peak, 41 000 cores)
 - ▶ Connect to EDF numerical code users (Code_Aster for example)
- ▶ Take benefit from the advanced visualization capability from Paraview
- ▶ Drive the GUI from a python script usable in an "expert" mode

PERSALYS, the graphical user interface of OpenTURNS

- ▶ Main goal : provide a graphical interface of OpenTURNS in the SALOME integration platform
- ▶ Features
 - ▶ Uncertainty quantification : definition of the probabilistic model (including dependence), distribution fitting (including copulas), physical model with vector input and vector output or 1D Fields, central tendency, sensitivity analysis, probability estimate, meta-modeling (polynomial chaos, kriging), screening (Morris), optimization, design of experiments
 - ▶ Generic (not dedicated to a specific application)
 - ▶ GUI language : English, French

Community

- ▶ Website <https://persalys.fr/?la=en>
- ▶ Forum <https://persalys.discourse.group>
- ▶ First user's day on November 14th 2023
- ▶ Commercialization by Phimeca consists in :
 - ▶ Providing training, support on projects
 - ▶ Developing customized versions (EDF, NavalGroup) or dedicated features (Thales, NavalGroup)

	Level 1	Level 2	Level 3
Content	<p>Provision of the source code and Windows or Linux executables, on request via the mail form. A new version is available at least once a year or when a major update is released.</p> <p>Persalys is also integrated into SALOME platform. You can download it from the SALOME website.</p>	<p>Purchase a 1-year support with access to the updates (minor version, bug fix).</p> <p>This level is a package of 1800€, excluding taxes. It includes 15h of assistance, divided according to your needs:</p> <ul style="list-style-type: none"> • Training (max. 1 day, for 2 users max.) • Support on projects <p>In need of more support? We provide a customised quotation.</p>	<p>Customised development in the interface:</p> <ul style="list-style-type: none"> • Custom physical model • Integration of specific methods • ... <p>Feel free to contact us to get a customised quotation depending on your need.</p>
Subscription	Free	1800 € excl. tax	Customised quotation

Summary

- ▶ Partners : EDF, Phimeca
- ▶ Licence : LGPL
- ▶ Schedule : new release twice a year
- ▶ Availability :
 - ▶ Stand-alone version : for free on demand on www.persalys.fr
 - ▶ SALOME_EDF in the "CONTRIBUTIONS" section since 2018 on <https://www.salome-platform.org>
 - ▶ Debian "bookworm" <https://packages.debian.org/source/bookworm/persalys>We thank Pierre Gruet (EDF) for this outstanding work!

Stepwise linear model - Definition

- ▶ Uses LinearModelStepwiseAlgorithm from OpenTURNS
- ▶ From a design of experiment or a data model

Methods to create metamodels

Design of experiments

datamodel

Sample size : 506

Outputs of interest

-- Select outputs --

MEDV

Method

☒ Linear regression

☐ Functional Chaos

☐ Kriging

Linear regression parameters

Parameters

Degree 2

Interaction ☒

Metamodel validation

Computation of the predictivity factor Q2

☐ Leave-one-out via analytical method

☒ By splitting data into training/test samples

Test sample size 20% of the design of experiments

Training sample size : 404

Seed 1

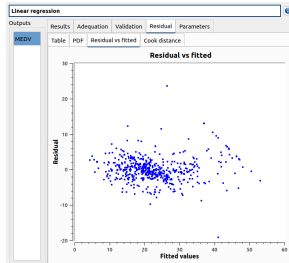
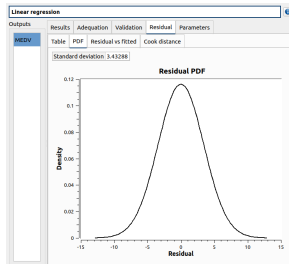
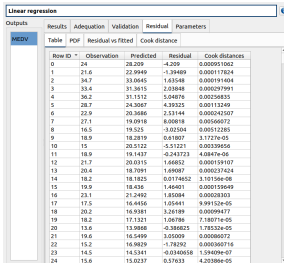
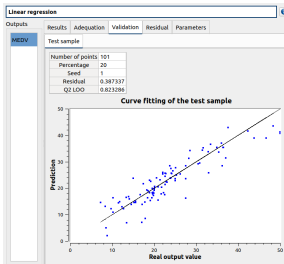
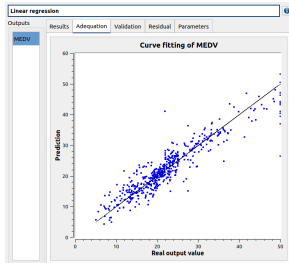
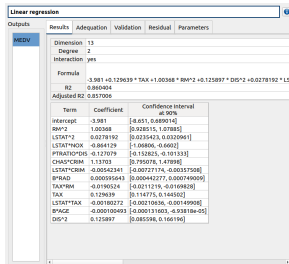
☐ By K-Fold method

Number of folds 5

Seed 1

http://openturns.github.io/openturns/latest/user_manual/response_surface/_generated/openturns.LinearModelStepwiseAlgorithm.html

Stepwise linear model - Results and validation



Optimization overhaul (1)

- ▶ Added constraints support
- ▶ Added variable type definition for mixed optimization

Add and define constraints

	Variable	Operator	Threshold
1	Y0	<	3

Inputs

	<input checked="" type="checkbox"/> Name	Description	Type	Fixed value	Lower bound	Upper bound
1	<input checked="" type="checkbox"/> X0		Continuous	0	0	5
2	<input checked="" type="checkbox"/> X1		Integer	0	0	5

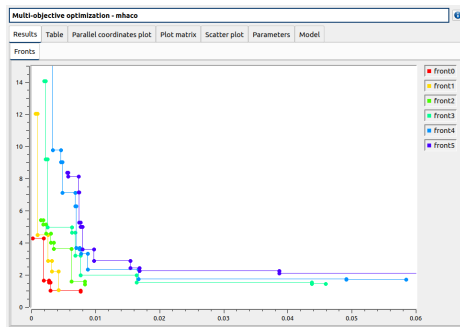
Optimization overhaul (2)

- Added multi-objective optimization analysis
As a service for NavalGroup
Evolutionary algorithms from Pagmo

Available algorithms

Name

- ☐ nsga2
- ☐ moead
- ☐ moead_gen
- ☒ mhaco
- ☐ nspso



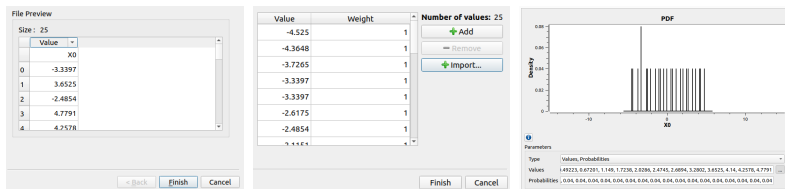
The figure shows the 'Multi-objective optimization - mhaco' interface with the 'Table' tab selected. The table displays the results of the optimization, including RowID, feasibility, front_index, X0, X1, Y0, and Y1. The table is sorted by RowID, and the first 16 rows are visible.

RowID	feasibility	front_index	X0	X1	Y0	Y1
0	0	0	0.00292112	0.00794428	0.00292112	1.04116
1	1	0	0.0018823	0.0793728	0.0018823	1.67421
2	2	0	0.00764005	0.0021053	0.00764005	0.996548
3	3	0	0.00269831	0.065765	0.00269831	1.55011
4	4	0	0.000164243	0.367553	0.000164243	4.28285
5	5	1	0.00085893	0.395735	0.00085893	4.50651
6	6	1	0.00419232	0.0126052	0.00419232	1.07647
7	7	1	0.00257331	0.216616	0.00257331	2.88525
8	8	1	0.00313271	0.142721	0.00313271	2.22757
9	9	1	0.000625562	1.23745	0.000625562	12.0555
10	10	2	0.00617232	0.0716423	0.00617232	1.59789
11	11	2	0.00827742	0.0523355	0.00827742	1.43241
12	12	2	0.00347279	0.301543	0.00347279	3.6311
13	13	2	0.00224153	0.409352	0.00224153	4.60166
14	14	2	0.00297937	0.344074	0.00297937	4.01264
15	15	2	0.0017856	0.472376	0.0017856	5.17048
16	16	2	0.00142007	0.499966	0.00142007	5.424

<https://esa.github.io/pagmo2/>

Miscellaneous features

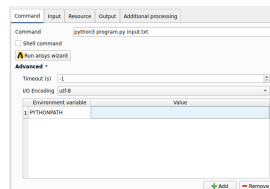
- ▶ Sampling using existing data



- ▶ NormalCopula can be parametrised w. shape and Kendall matrices (only Spearman was available)

Miscellaneous features

- ▶ Coupling model command environment override



- ▶ Gradient evaluation

Definition

Differentiation

Finite difference step definition

Variable	Step
1 x1	1e-07
2 x2	1e-07
3 x3	1e-07

Gradient values

	y0	fake_y0	y1
x1	-0.0499167083234	-0.0499167083234	-0.0499167083234
x2	0.362357754477	0.362357754477	0.362357754477
x3	0	0	1

Evaluate model

Evaluate gradients

► Inference :

- Optional distribution parameters confidence interval estimation
- Lilliefors fitting test (only Kolmogorov-Smirnov was available)

Marginals inference				
Variables				
Summary				
Distributions				
Distribution	Bayesian Information Criterion	p-value	Acceptation (0.1)	
<input checked="" type="radio"/> Beta	9.57	0.958	yes	
<input type="radio"/> Uniform	9.62	0.0426	no	
<input type="radio"/> Trapezoidal	9.62	0.0448	no	
<input type="radio"/> WeibullMax	9.68	0.0277	no	
<input type="radio"/> Normal	9.72	0.000102	no	
<input type="radio"/> LogNormal	9.73	0.0001	no	

PDF/CDF		Q-Q Plot		Parameters	
Parameters		Parameters confidence interval			
α	2.2386	1.83164	2.496		
β	1.38123	1.21516	1.56949		
a	312.103	308.589	320.25		
b	449.577	448.941	449.586		
Moments					
Mean	397.121				
Standard deviation	31.0699				
Skewness	-0.372962				
Kurtosis	2.27076				

► Design of experiment error handling

Design of experiments				
Summary				
PDF/CDF				
Box plots				
Dependence				
Table				
Parallel coordinates plot				
Plot matrix				
Scatter plot				
Parameters				
Model				
Table				
Failed points				
Error messages				
Parallel coordinates plot				
Scatter plot				
Size : 3				
Row ID	Error message			X0
0 0	Python exception:\nTraceback (most recent call last):\n File "<string>", line 4, in _exec\nValueError: math domain error\n			-5.000000
1 1	Python exception:\nTraceback (most recent call last):\n File "<string>", line 4, in _exec\nValueError: math domain error\n			-2.500000
2 2	Python exception:\nTraceback (most recent call last):\n File "<string>", line 4, in _exec\nZeroDivisionError: float division by zero\n			0.000000

Miscellaneous features

- ▶ Confidence interval length as analysis stopping criterion
- ▶ Sample tables partial copy pasting
- ▶ Ansys intermediate parameters detection

- ▶ Coming soon
 - ▶ Data field model
Import model mesh and data from already evaluated field samples
 - ▶ Calibration QQ-plots

- ▶ Design of experiments overhaul
- ▶ Detach-attach jobs on distant cluster - interrupt (instantly) running analysis
- ▶ Python/YACS physical models merge

The end

Thanks !

Questions ?