

PROBABilistic computational intelLIGENCE

using STOCHOS inside optiSLang

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PI Probaligence GmbH

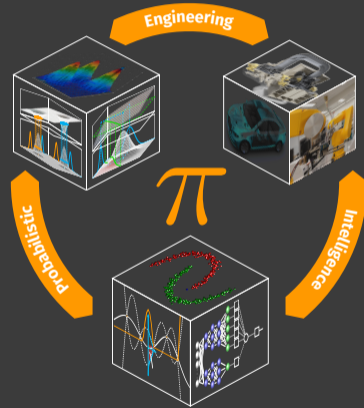
June 1, 2021



STOCHOS inside optiSLang

The (short) story of π founded in late 2018

- University spin-off.
- Make research results available to industry.
- Guarantee **maintenance, support and further development**
- π provides the **reliability** of an industry company and the **innovation** of an research faculty.



STOCHOS inside optiSLang

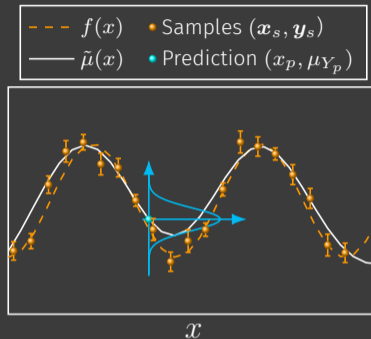
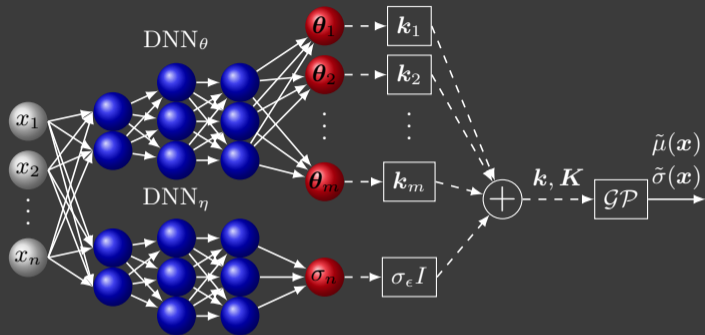
The screenshot displays the optiSLang software interface. The main window shows a project named "Unnamed project" with a menu bar (File, Edit, Project, View, Help) and a toolbar. The central area contains a "BayesianOptimization" wizard and a "Calculator" icon. A "MOP" icon is also visible. A "Wizards" panel on the right lists various optimization wizards, including "Sensitivity wizard", "Optimization wizard", "Robustness wizard", and "Reevaluation wizard". The "Modules" panel on the right shows a search bar and a list of modules, including "Add-Ins", "BayesianOptimization", "Reevaluate", "Process chain elements", "Analysis", "Metamodelling", "MOP", "Calculator", "Data Mining", "Monitoring", and "Postprocessing".

The "MOP" wizard is open, showing the "Settings" tab. The "Database file" is set to "Absolute path". The "Use advanced settings" checkbox is checked. The "Advanced Settings" tab is selected, displaying a table of properties and values:

Property	Value
Testing type	Cross validation
Approximation type	Smoothing
Resampling for single CoPs	Empirical distribution from data
Max. responses in parallel	4
Use incomplete designs	<input checked="" type="checkbox"/> True
Export FMU after MOP creation	<input type="checkbox"/> False
> Adapt bounds (incl. reference value if necessary)	
> CoP tolerance	
> Transformation	
Models	
> Polynomials	
> Moving least squares	
> Kriging	
External	
ASCMO	<input type="checkbox"/> False
DIMGP	<input checked="" type="checkbox"/> True
DIMGP_Classifier	<input checked="" type="checkbox"/> True
Simal.MOP	<input type="checkbox"/> False

The "Show postprocessing" checkbox is unchecked. At the bottom of the wizard, there are "OK", "Cancel", and "Apply" buttons. The "Show additional options" checkbox is checked.

Deep Infinite Mixture Gaussian Process (DIM-GP)

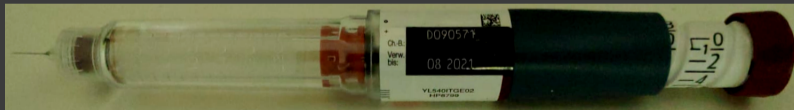
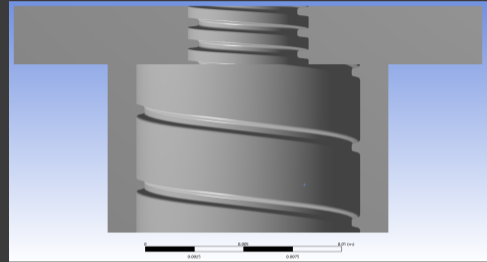
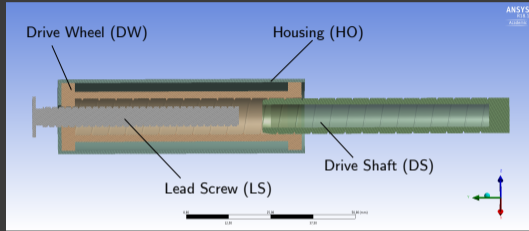


Output / Input	Scalar	Vector	Matrix	Tensor
Scalar	xyz	xy	x	x
Vector	x	x	x	x
Matrix	x	x	x	x
Tensor	x	x	x	x

- x: Supported by STOCHOS python module
- y: Supported by BayesianOptimization - OSL
- z: Supported by MoP - OSL

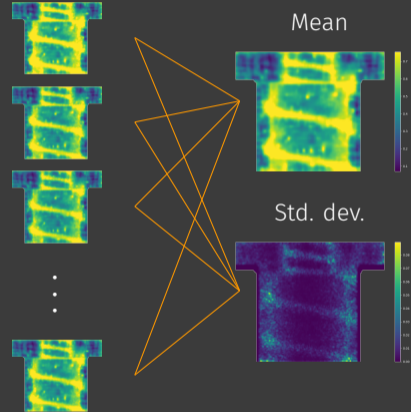
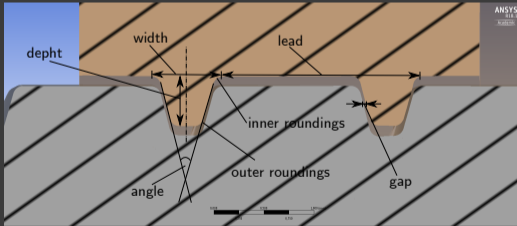
Learning the tolerance distribution from images

Insulin pen design

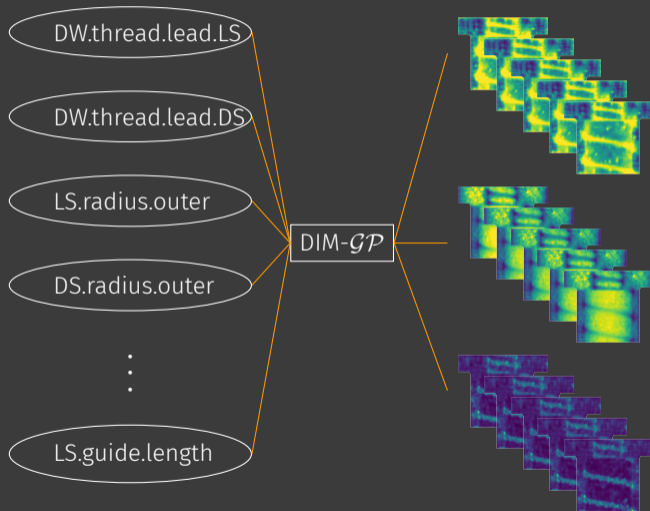


Design and tolerance representations

Lead Screw	Drive Shaft	Drive Wheel
LS.thread.x ×6	DS.thread.x ×6	DW.thread.x.LS ×6
LS.radius.outer	DS.radius.outer	DW.thread.x.DS ×6
LS.guide.length	DS.guide.length	DW.thread.gap.LS
LS.length	DS.length	DW.thread.gap.DS
LS.head.width	DS.wall.thickness	DW.length
LS.head.radius		DW.wall.thickness



Parameters to tolerance field



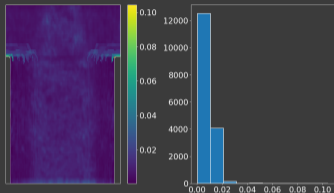
- Geometric model parameters as inputs
- Train DIMGP to predict the tolerance fields
- Input shape: (27)
- Output shape: (120, 160, 3)

→ scalar to tensor model

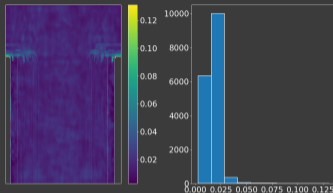
Parameters to tolerance field - Train Errors (80 designs, 874 samples)

Mean

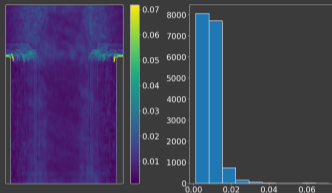
$R^2 = 0.971$



$R^2 = 0.986$

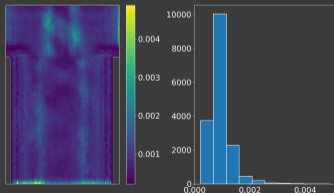


$R^2 = 0.995$

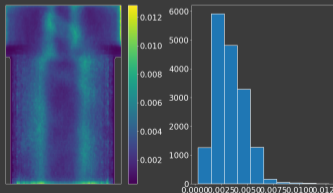


Std. Dev.

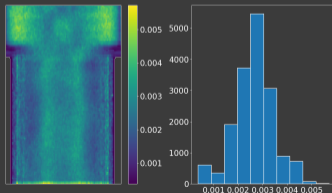
$R^2 = 0.815$



$R^2 = 0.777$



$R^2 = 0.675$



Channel 1

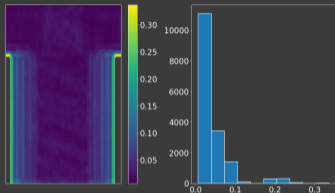
Channel 2

Channel 3

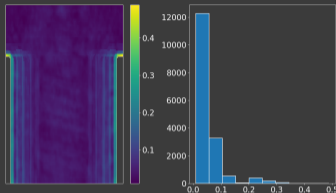
Parameters to tolerance field - Test Errors (20 designs, 217 samples)

Mean

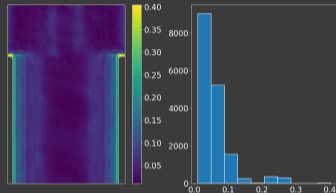
$R^2 = 0.504$



$R^2 = 0.871$

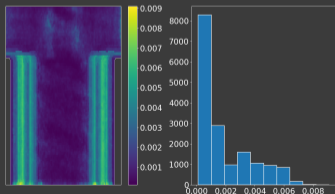


$R^2 = 0.848$

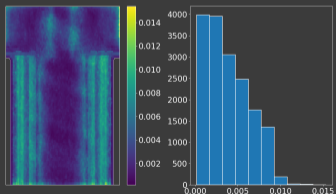


Std. Dev.

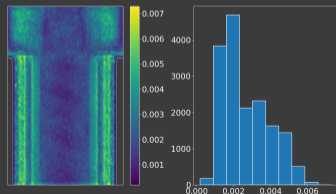
$R^2 = 0.011$



$R^2 = 0.650$



$R^2 = 0.449$

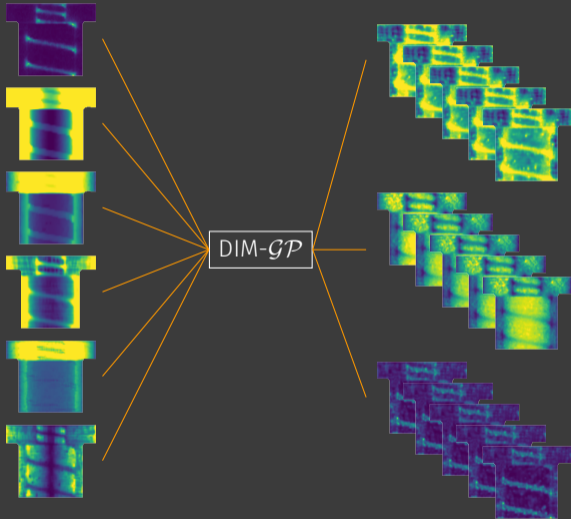


Channel 1

Channel 2

Channel 3

Geometry image to tolerance field



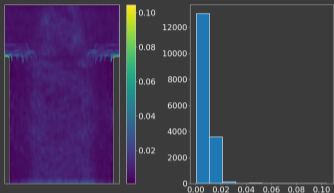
- Geometric properties (coordinates, normal vector components, curvature) as input image channels
- Train DIMGP to predict the tolerance fields
- Input shape: (120, 160, 6)
- Output shape: (120, 160, 3)

→ **tensor to tensor** model

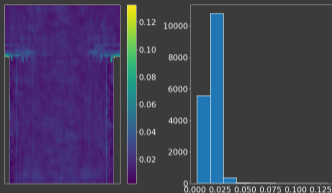
Geometry image to tolerance field - Train Errors (80 designs, 874 samples)

Mean

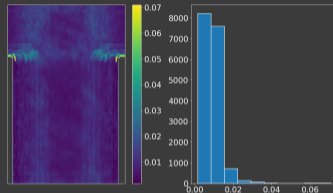
$R^2 = 0.971$ (0.000)



$R^2 = 0.986$ (0.000)

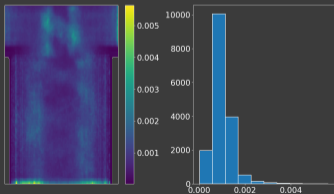


$R^2 = 0.995$ (0.000)

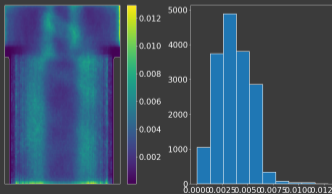


Std. Dev.

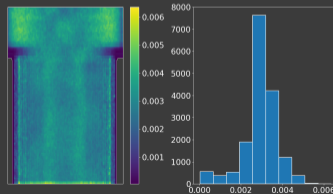
$R^2 = 0.787$ (+0.776)



$R^2 = 0.736$ (-0.040)



$R^2 = 0.626$ (-0.049)

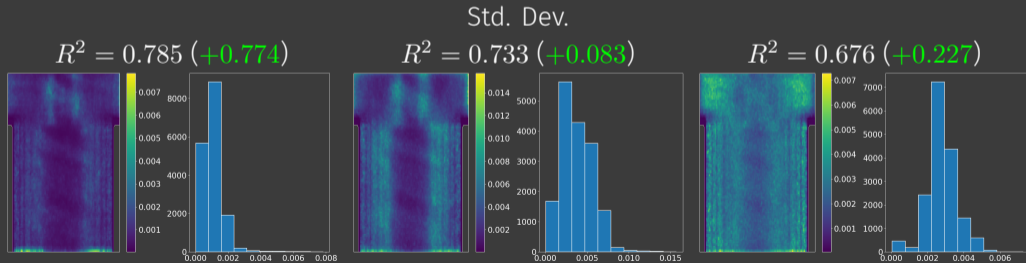
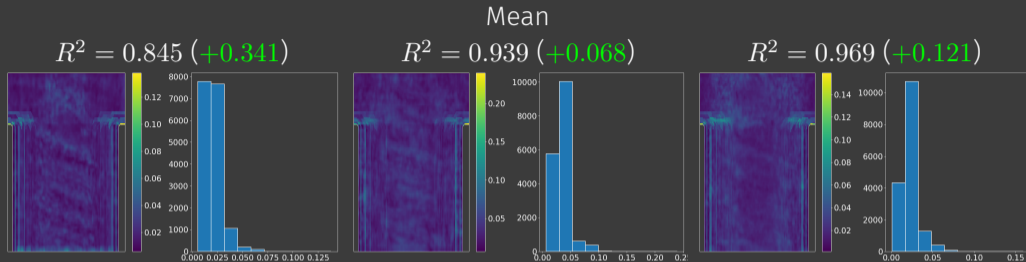


Channel 1

Channel 2

Channel 3

Geometry image to tolerance field - Test Errors (20 designs, 217 samples)

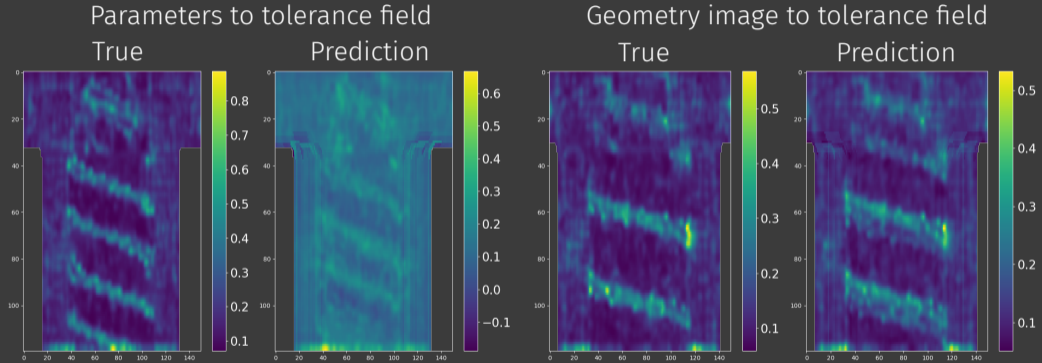


Channel 1

Channel 2

Channel 3

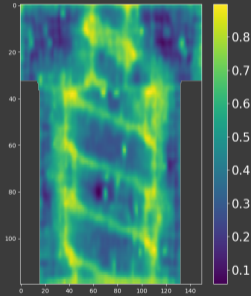
Comparative results (Median sample) - Channel 1



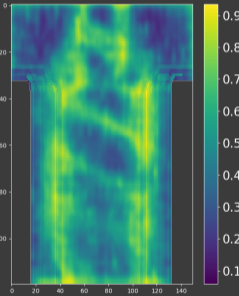
Comparative results (Median sample) - Channel 2

Parameters to tolerance field

True

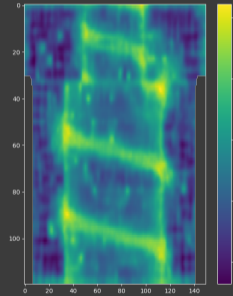


Prediction

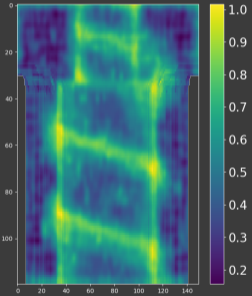


Geometry image to tolerance field

True



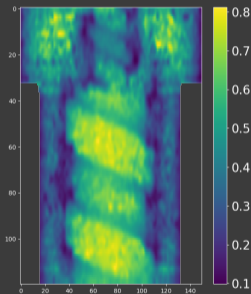
Prediction



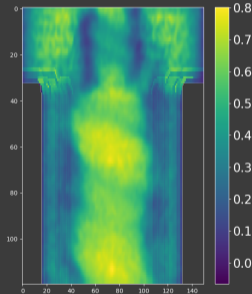
Comparative results (Median sample) - Channel 3

Parameters to tolerance field

True

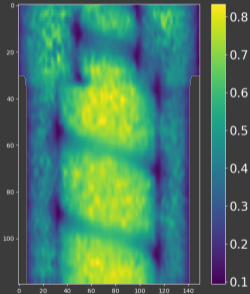


Prediction

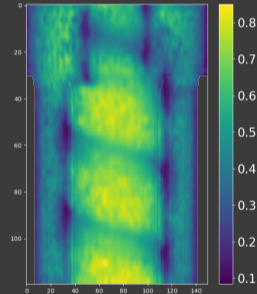


Geometry image to tolerance field

True



Prediction



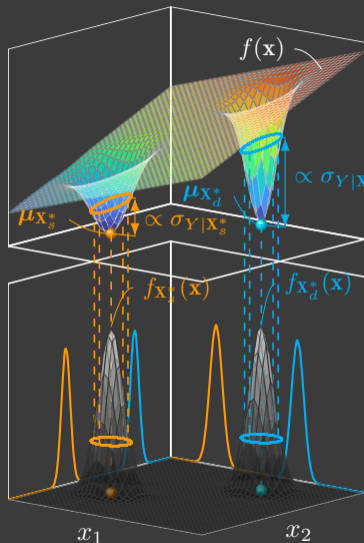
Conclusion and Outlook

Conclusion

- DIM-GP can be trained using arbitrarily shaped data
- Image representation may be more informative than CAE parameters
- Other parametrizations may achieve better results
- Using a better parametrization scheme enables using RDO tools in optiSLang
- WIP: Support non-scalar data in STOCHOS inside optiSLang
- Next step: RDO

Outlook

- BayesianOptimization add-in for sample efficient optimization
- Sobol-index embedded Bayesian optimization (SIEMBO) can be used for optimization in high dimensional image space instead of the parametric one
- WIP: Bayesian robust design optimization for STOCHOS inside optiSLang
- STOCHOS license includes both models and algorithms



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