modeFRONTIER v4.3 and Beyond

Product Roadmap

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modeFRONTIER v4.3.0 Overview

- **Key Features:**
  - **Workflow Nodes** for the extended process integration
  - **Optimization Algorithms** for fast and global search
  - **Design Space and Data Mining Tools** for improved design assessment
Process Integration
Nodes supported:
ANSYS Workbench, UGS NX, NI LabVIEW, SimulationX

New Nodes in 4.x family:
DOS Batch, SH Script, Matlab, Excel, Catia, GTSuite
1. The job starts on a grid node
2. modeFRONTIER distributes the job on grid machines available
3. The controlling grid node gets results back
The new ANSYS Workbench 12 node

Technical Features:

- ANSYS Workbench v12.1 supported
- Handling of Input/Output Parameters defined in Workbench Parameter Set
- Pre-processing macro functionalities available to detect geometry failure, check mesh quality or similar
- Post-processing macro functionalities available for advance assessment of results
- Support GridGain system for distributed computing
The new METAPost node

Technical Features:

- METAPost v6.4.0 or greater
- METAPost can be used to extract responses for the optimization problem
- Several FEA output file reading supported (incl. NASTRAN, ABAQUS, LS-Dyna, Pamcrash, Radioss, Madymo, etc.)
The METAPost node (2)

OUTPUT results:
- Real Scalar History
- Real Vector History (X,Y history curve), Complex Vector History (Frequency, Magnitude and Phase)
Process Integration: New SimulationX node (1)

Technical Features:
• SimulationX v3.3 or greater
• Components and Connections parameters input/output parsing
• Grid-enabled for distributed computing
Process Integration: New SimulationX node (2)

**INPUTS:**
- Scalar component/connection parameters
- Component Tables defined via matrix variables

**OUTPUTS:**
- Scalar output parameters:
  - MIN
  - MAX
  - MEAN
  - LAST
- Vector output curves
**Additional Integration nodes**

**NEW FEATURES:**
- New node for coupling with OCTAVE environment
- **SoC** node for System-on-a-Chip design

**IMPROVEMENTS:**
- **Flowmaster node:**
  - Ambient conditions available as input
  - Custom Unit set selection
- **GT-SUITE/ANSA Node:**
  - New license check option before the run starts
- **ProEngineer Node:**
  - PRT and ASM versioning control
- **Script Nodes:**
  - Timeout option
The new Lookup Table node

- **Problem**: given a set of inputs \(X=(X_1, X_2, \ldots, X_n)\), and a reference sets of data (i.e. any table in the Design Space):
  1. The **Lookup Table** node finds closest \(X\) for a given set of inputs.
  2. The **Lookup Table** node returns \(Y=(Y_1, \ldots, Y_m)\) corresponding to the point which best matches \(X\).

- **Benefits**: SOM Table can be used in the Workflow to find BMU to **classify** sets of data for each iteration of the scheduler selected

<table>
<thead>
<tr>
<th>X1</th>
<th>X2</th>
<th>X3</th>
<th>X4</th>
<th>Out1</th>
<th>Out2</th>
<th>Out3</th>
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<td>3.090614</td>
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</tr>
</tbody>
</table>
• **Case Study**: highly nonlinear optimization problem requires different RSM training for local accuracy
• For each cluster of solutions a different Response Surface is created
• **Question**: how to select the best Response Surface model to estimate response value based on input parameters values?
Answer: use the **LookupTable** node in the Workflow as follows:

- Define as matching criterion the cluster ID for a given SOM clustered table
- A different RSM is loaded based on value of the matching cluster ID
Workflow Creation Wizard

The Workflow Creation Wizard lets you quickly and easily create simple template workflows including:

- Input/Output variables
- Input/Output vectors
- File nodes
- Application nodes
- DOE and Scheduler nodes
Workflow Creation and Edit from Excel (1)

- Variable nodes defined in Excel can be imported into modeFRONTIER for automatic Workflow creation
- Variable nodes settings can be exported to Excel
- Variable nodes settings can be edited in Excel and imported into modeFRONTIER
Workflow Creation and Edit from Excel (2)

- Import/Export of variable settings is available for:
  - Vector Input Variable
  - Vector Output Variable
  - Vector Objective
  - Vector Constraint
Custom Workflow Library

- The number of D/I nodes is growing by the day, thus visualization needs to become simpler.
- Custom selective view of the Workflow nodes library is now available.
- Custom library view can be restored at anytime.
Optimization Algorithms
NSGA-II Enhancements

- **New features:**
  - Improved NSGA-II version to support unordered discrete variables for mixed-integer problems
  - New schemes added:
    - **Controlled Elitism** to increase uniformity distribution of Pareto front
    - **Variable Population Size** for higher accuracy of approximated Pareto front
    - **Steady State Evolution (MFGA):** steady state evolution with an adaptive elitism procedure for an efficient parallelization scheme
External Schedulers Bridge

- Bridge to external optimization algorithms
- 3rd Party tools supported:
  - MATLAB (www.mathworks.com)
  - Scilab (www.scilab.org)
  - Octave (www.gnu.org/software/octave)
  - Runtime library to exchange data between modeFRONTIER and 3rd party tool
- The user can easily integrate custom optimizers with modeFRONTIER
Benefits: mixing existing algorithms for custom search

Results:
1. Original NBI-AFSQP version by modeFRONTIER
2. Random search powered by MATLAB
3. Desired search area powered by MATLAB
New Fast Algorithms

- New FMOGA-II and FSIMPLEX exploit an efficient set of internal adaptive Response Surface Method.
- Combination of adaptive RSM, Incremental Space Filler DoE and optimization algorithms for cost-effective design optimization
- Parallel RSM training using multi-thread technology
Other Enhancements

- MOSA:
  - Support unordered discrete variables
  - Steady-state evolution option

- Evolution Strategy:
  - Support unordered discrete variables
Design Space
Evolutionary Design - RSM Parallel Creation

New Features:

- Each RSM job evaluation can be performed in parallel mode
- Multi-threading RSM training to exploit multi-core system computational capabilities
- The user can specify desired number of CPUs for RSM training
New Features

- Threshold Filter
- New correlation coefficients:
  - Spearman
  - Partial Correlation
  - Partial Ranking Correlation
RSM Multiple Function Plot

Different RSM functions plotted on the same chart

Sliders changes inputs interactively

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Design Space visualization charts can be saved to a XML Template file and reused for different projects.
CAP: Design Principle Extraction Tool

Computer Aided Principles

- Attention on effects (trends) of combinations of multiple variables.
- Data classification based on characteristic value (clustering).
- Visually representation of trends in description variables, (characterizing each cluster).
- Visually representation of variations among the trends in the description variables.

modeFRONTIER is not only able to find what is the optimum, but why it is optimum.

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Visualization Concept

Workflow Editor

Data Management

Assessment Module

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1. Improvements & New Features
2. Bridging
3. User interface
Improvements: Renewing The Tools

**MCDM Tool**
- Wizard based
- Supporting all tables

**RSM Tool**
- Automatic outliers removing
- Mark Outliers Option
- Repeated designs handling
New Features: Numeric Tools

- RS Validation
  - Independent Test Set
  - Validation statistics summary tables

Mixture Experiments (DOE)
- Tailored for mixtures
- Components in proportions

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New Features: Multi Variate Analysis

Support Vector Machine
- Classification analysis
- Regression problems

Spectral Clustering
- Reduce dimensionality
- Transitive relations
New Features: Algorithms Selection Tool

- Guided Scheduler/DOE selection
- Problem definition
- Algorithms Rankings
- Customizable selection rules.
Improved CAP Tool

Computer Aided Principles

- Cluster Trend Recognition
- Relationships among Designs
- Sampling Definition
Bridging: external applications exploitation

- A console as a bridge-head to 3rd party math environments
- Expert users
- Customized functions and plotting
- Examples: 'R', Python, Matlab
External viewer

- Standalone application based on modeFRONTIER 5 engine (without the optimization engine)
- Compatible to modeFRONTIER .prj file
- Display datasets, graphics, and documentation
- Create postProcessing charts and functions
User interface: ribbon taskbar

- Quick access toolbar
- Contextual task group
- Keyboard navigation and key tips
- Rich tool tips
- Resize, collapse and scrolling supported
- Simpler layout
- Easy drag & drop interface
- New charts and nodes classification
- Standard behavior for all modules
User interface: new layout

New Tools Environment

New charts libraries

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modeFRONTIER 5
Integration Concepts
Integration Concepts

Development of the Run Engine and integrations of Third Party Softwares

- Process Engine
- Workflow Framework
- Process Integration
- Grid Framework

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API - Application programming interface

- “bridge” between customer needs and mF
- full library of objects and methods
- build up new workflow and call a new optimization run
- script console
new Scripting API example
Hardware-in-the-loop integrations

- LabVIEW integration
- Real-world optimization runs
- Signal processing, automation control, test systems

[Diagram of integration process]
Grid extension

More nodes in the grid

- direct integration node on a software installed in a local network
- all the most important direct integrations
- enhance the grid manager tool
Simplify common tasks - 1

New engine
✓ more scalable
✓ more robust
✓ new process table
Simplify common tasks - 2

New Filesystem
- fewer levels in the directories tree
- different log levels
- aiming to a brand new Run Log
Simplify common tasks - 3

New Parameter Chooser

✓ one-click
✓ clearer selection
✓ build up a workflow immediately
modeFRONTIER 5 Numerics
New improved version of **Sobol** DOE:
- it can manage over 20000 input variables

New improved version of **Reduced Factorial** DOE:
- implements a *Resolution V* algorithm for better statistical analysis

New improved version of **MACK** Scheduler:
- more control over internal RSM training

New improved version of **SIMPLEX**
- better constraint handling

New improved version of **MOGT** Optimizer:
- more efficient variables decomposition

New **RSM** algorithms to be introduced or improved
Brand new algorithm for managing many variables: **Morris-EE Scheduler**

- It is a screening method: it is used for reducing the dimensionality of the input space, and identifying the more-important input parameters at a low computational cost.
Brand new hybrid optimization algorithm to be introduced:

• It combines different optimization algorithms in one single scheduler

• It improves both robustness by using heuristic optimizers, and accuracy by using gradient-based optimizers
New Sensitivity Analysis tool

Sensitivity Analysis is the study of how the variation (uncertainty) in the output of a mathematical model can be apportioned, qualitatively or quantitatively, to different sources of variation in the input of the model.

It is a technique for systematically changing parameters in a model to determine the effects of such changes.
Thank you!

For further information, please contact:

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