Vorstellung von LS-OPT® Version 5

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Outline

- Overview of methodologies and applications of LS-OPT
  - DOE/Sensitivity analysis
  - Parameter identification
  - Shape optimization
  - Robustness analysis
- Live demonstration of Graphical User Interface of LS-OPT V5
- Visualization of optimization results
Introduction

→ About LS-OPT

- LS-OPT is a standalone optimization software
  → can be linked to any simulation code
    - Interface to LS-DYNA and MSC-Nastran
    - User-defined Interface
- Current production version is LS-OPT 5.0
- LS-OPT Support web page
  → www.lsoptsupport.com
  - Download of Executables
  - Tutorials
  - HowTos / FAQs
  - Documents
  - ….
Introduction

➡ About LS-OPT – General Aspects

- Job Distribution - Interface to Queuing Systems
  - PBS, LSF, LoadLeveler, SLURM, AQS, User-defined, etc.
- LS-OPT might be used as a “Process Manager”
- Shape Optimization
  - Interface to LS-PrePost, ANSA, HyperMorph
  - User-defined interface
- META Post interface
  - Allows extraction of results from any package (Abaqus, NASTRAN, …) supported by META Post (ANSA package)
Introduction

About LS-OPT

- LS-DYNA Integration
  - Checking of LS-DYNA keyword files (*DATABASE_)
  - Importation of design parameters from LS-DYNA keyword files (*PARAMETER)
  - Support of include files (*INCLUDE)
  - Monitoring of LS-DYNA progress
  - Result extraction of most LS-DYNA response types
  - D3plot compression (node and part selection)
LS-OPT – Overview Methodologies

- Response Surface Method (RSM)
  - Sequential Response Surface Method (SRSM)

- Metamodels
  - Polynomials
  - Radial Basis Functions
  - Feedforward Neural Networks …

- Genetic Algorithm (MOGA->NSGA-II)
  - Direct
  - Metamodel-based

- Monte Carlo Analysis
  - Direct
  - Metamodel-based
Applications of LS-OPT

- **Optimization**
  - **Size-/Shape optimization**
  - **Constraints**
  - **Mixed continuous/discrete variables**
    - Specify sets of discrete variables (e.g., sheet thicknesses)
  - **Multiple load cases**
    - Multi-disciplinary optimization (MDO)
  - **Multi-objective optimization (Pareto Frontier)**
  - **Reliability based design optimization**
  - **Methodologies**
    - Meta-model based approaches
    - Genetic Algorithms (MOGA->NSGA-II)
Applications of LS-OPT

- **Parameter/System Identification**
  - *Calibration of test and simulation curves or scalar values*
  - *Visualization of test and simulation curve for comparison*

\[
\frac{1}{P} \sum_{p=1}^{P} W_i \left( \frac{F_i(x) - G_i}{s_i} \right)^2
\]

![Graph showing comparison between start and optimized results](image)

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![Graph showing comparison between start and optimized results](image)
Applications of LS-OPT

Parameter Identification with Test Curves

Computed curve: $F(x, z)$

Interpolated test curve $G(z)$

Test results

Residual $e_i$

Map

Computed curve

Target curve

$F(z)$

$G(z)$

$z$

$F(x, z)$

Test results

Interpolated test curve $G(z)$

Residual $e_i$
Applications of LS-OPT

- Computed history curves vs. Target curves
Applications of LS-OPT

- DOE-Studies, Design Exploration
  - Visualization: 2D/3D sections of the surfaces, 1 or 2 selected variables vs. any response
Applications of LS-OPT

- Sensitivity Studies (ANOVA, Sobol)
  - Contribution of variables to system performance
  - Identification of significant and insignificant variables
  - Ranking of importance

![Global Sensitivities Plot](image)
Applications of LS-OPT

- Robustness/Reliability Analysis
  - Consideration of uncertainties
  - Evaluation of reliability (probability of failure)
  - Statistics (mean, std, …)
  - Correlation analysis
  - Confidence intervals
  - Outlier analysis
  - Fringe statistical results on FE model

PDF

response

permitted fraction
failing fraction

standard deviation of y-displacement
Applications of LS-OPT

- Robust Parameter Design (RDO)
  - Improve/Maximize the robustness of the optimum

- Reliability Based Design Optimization (RBDO)
  - Improve failure probability of optimum
Sequential Response Surface Method (SRSM)
Methods - Optimization

Response Surface Methodology - Optimization Process

- Design space
- Design variable 1
- Design variable 2
- Objective
- Response surface
- Response values
- Experimental design points
- Subregion (Range)
- Starting (base) design

Experimental Design points
Methods - Optimization

Find an Optimum on the Response Surface (one iteration)

- Optimization of sub-problem (response surface) using LFOPC algorithm
- Starting value on response surface
- Optimum (predicted by response surface)
- Optimum (computed by simulation using design variables)
Successive Response Surface Methodology

Methods - Optimization
Outlook LS-OPT 5.1

- Interface to Excel as a stage
- Multi-level optimization
  - Define LS-OPT as a stage
- Deactivation of variables
  - Seamless deactivation between iterations
- Response variables
  - Transfer of output variables (responses) from one stage as input variables to the next stage
- Collaborative optimization
  - De-activate selected cases in an MDO problem
  - Allows synthesis and decomposition of MDO setup
- Mathematical formulas of meta-model functions
- Global Sensitivity Analysis in sub-domain of design space