Optimization and Probabilistic Design Using LS-OPT

Objective:

This 3.5 day course provides an introduction to the use of the optimization code LS-OPT for optimal design and probabilistic analysis. It covers both theoretical concepts and practical aspects of design optimization and probabilistic analysis. An emphasis is placed on interfacing with LS-DYNA. Advanced topics such as multiobjective and collaborative optimization and optimization under uncertainties are also covered. The course includes workshop sessions in which the theoretical topics of the day are applied. The LS-OPT Version 5.1 graphical user interface is used to teach input preparation and post-processing.

Audience:

This course is intended to enable engineers with basic knowledge of LS-DYNA to become more productive in design and parameter identification, and to get an insight into the design reliability. An introductory class in LS-DYNA is recommended for familiarity with a few keywords, but is not a necessary prerequisite. Optimization knowledge is not required.

Notes:

The instructor for this course is Dr. Anirban Basudhar. Lectures begin daily at 9:00 a.m. and run until 5:00 p.m., except for the last day when the course concludes at 12:00 p.m. The classroom machines are PCs running Linux (CA) or Windows (MI). Over the duration of the class, students work individually (sometimes in groups of two) to solve the exercises. The exercises are simple, so that they take a short time to run, but contain enough complexity to give insight into the optimization process. Most of the problems are nonlinear (large deformation) dynamic and will be solved using LS-DYNA simulation.

Contents

Day 1

- Course outline
- Introduction to Design optimization using industrial examples
- LS-OPT features

- Optimization Theory:
    - Optimization fundamentals
    - Response Surface Methodology
    - Experimental Design
    - Metamodeling
    - Design model adequacy checking
    - Optimization strategies
    - Sensitivity analysis and variable screening
    - Optimization examples
- Running LS-OPT and using the post-processor
    - Studying the different LS-OPT components using the GUI setup of a simple optimization example and running the example
    - Post-processing using the viewer, e.g. simulation and approximation results, optimization history etc.
- Simple optimization with LS-DYNA stage
    - Setting up a simple optimization with LS-DYNA stage from start
    - resource allocation
    - sampling, metamodeling and stage options
    - LS-DYNA interface features, e.g. ASCII database, binary database, filtering, time history functions, injury criteria
    - composite functions
    - simple design optimization formulation
    - program execution
    - job monitoring
    - database and output
    - post-processing using the viewer

Day 2

- Simple optimization setup and post-processing
    - continue post-processing using the viewer if not completed
    - restarting the simple optimization with additional constraint
- Setting up and running a sequential optimization
- Discrete optimization
- Optimization with user defined stage/solver
- Importing analysis results table
- Direct Optimization
- Theory
    - Parameter Identification using curve matching
    - Multidisciplinary Optimization (MDO)
    - Mode tracking

- Setting up, running and post-processing material parameter identification examples
- Variable screening and MDO with reduced variables

Day 3

- Advanced optimization theory
    - Multiobjective Optimization (MOO)
    - Multilevel Optimization (optional)
- Setting up and running MOO example - construct Pareto Front
- Post-processing MOO problems
    - Trade-off Plot
    - Parallel Coordinate Plot (PCP)
    - Self Organizing Maps (SOM)
    - Hyper Radial Vizualization (HRV)
- Probabilistic analysis and optimization theory
    - Statistics fundamentals
    - Probabilistic analysis methods
    - Reliability-based design optimization (RBDO)
- Direct Monte Carlo Analysis
    - Noise Variables
    - Statistical distribution
    - Latin Hypercube Sampling
    - Failure probability calculation
    - Statistical post-processing tools
    - DYNAStats
- Metamodel-based Monte Carlo Analysis
    - Reliabilibility calculation with noise variables and control variables
    - Statistical post-processing tools
    - Stochastic contribution
    - DYNAStats

Day 4

- Reliability-based design optimization
    - Optimization of Control Variables
    - Target probability of failure
- Robust design
    - Noise and Control variables
    - Standard deviation composite
    - Minimize effect of noise variables

- Stochastic Fields
- Outlier Analysis
- Metal Forming
- Tolerance Optimization (optional)