» A FICO™ Xpress Optimization Suite module

Xpress-SLP

decision management tools

Solve complex nonlinear problems

Xpress-SLP is a solver for nonlinear problems. It uses *successive linear approximation*, which has been developed from techniques used in the process industries, and is capable of solving large problems with many thousands of variables.

Availability

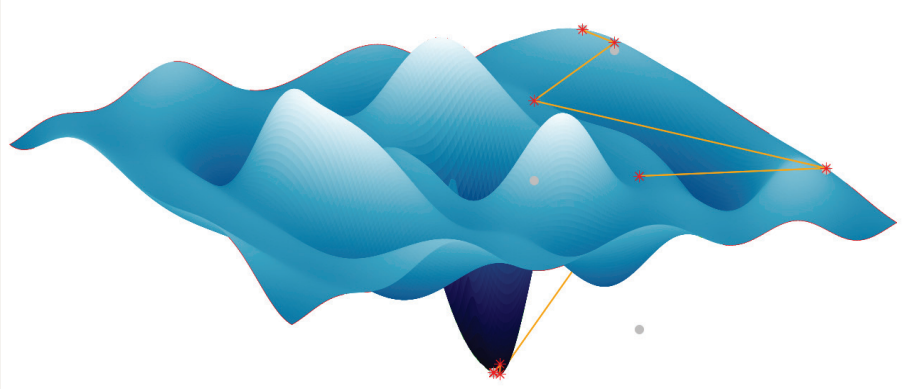
Xpress-SLP is available as an optional add-on for users of FICO™ Xpress Optimization Suite.

To learn more about Xpress, go to *www.fico.com/xpress*.

"In developing our new supply chain toolset, we looked at many optimisers and FICO's Xpress-SLP came top in our rankings. Throughout, we have been impressed by the expertise and responsiveness of the FICO team in supporting our use."

—Matthew Webster, CEO, Spiral Software

Minimization over a non-convex, nonlinear surface with Xpress-SLP



Xpress-SLP solve using large initial trust region steps to avoid locally optimal solutions. Trajectory on the surface is represented by orange lines; solutions to actual SLP approximations are represented by grey dots, and projected solutions are represented by red stars.

SLP stands for Successive Linear Programming, which is a method of solving a wide class of problems, called nonlinear optimization problems.

SLP is a proven technique that utilizes an embedded linear optimizer that solves nonlinear problems. Such problems are common in a wide range of vertical and horizontal applications. These include:

- Operations and strategic planning
- Supply chain planning and execution
- Pooling problems
- Marketing
- Retail
- Process industries
- Financial services

Nonlinear problems differ from linear problems. They are more complex and consequently more difficult to solve. Compared to linear problems of the same size, solving nonlinear problems takes much longer, if they can be solved at all.

Historically, many problems that are initially nonlinear have been necessarily simplified because LP methods have been reliable and capable of solving very large problems.

With the advent of an SLP framework that is reliable and capable of solving large problems, a whole new class of problems—and, in many cases, the real problem, rather than the simplified version—can be solved.

In very simple terms, linear problems can be represented by collections of straight lines made up of simple terms such as "production cost is $15/unit." Nonlinear problems can be thought of as collections of curves or tabular data, or equations, and have more complex terms such as "production cost varies as a function of quantity made." Almost all real-world problems have some nonlinear characteristics.

» Why SLP?

There are a number of methods available to solve nonlinear problems. SLP stands out because it:

- **Has gained a solid track record** in the process and manufacturing sector solving large planning and supply chain optimization and pooling problems.
- **Is very fast and efficient** for problems that contain some linear terms, as almost all nonlinear problems do.

- **Scales well in respect to model sizes.** Solution times scale especially well to the addition of large quantities of linear constraints.

» Xpress-SLP Technology

Xpress-SLP uses Successive Linear Programming to solve nonlinear models. In essence, the technique involves making a linear approximation of the original problem at a chosen point, solving the linear approximation and seeing how "far away" the solution point is from the original chosen point. If it is "sufficiently close" then the solution is said to have converged and the process stops. Otherwise, a new point is chosen, based on the solution, and a new linear approximation is made.

The Xpress-SLP solution:

- **Integrates with Xpress-Optimizer**—the leading commercial product for large-scale optimization—inheriting the strengths of Xpress-Optimizer, including speed, ability to solve large problems and reliability. The integration allows Xpress-SLP to separate parts of the nonlinear problem that can be solved by purpose written algorithms implemented in Xpress-Optimizer, and by so reducing the degree of nonlinearity to be handled by Xpress-SLP.
- **Is extremely feature rich and customizable.** Several facilities of Xpress-SLP allow for the inclusion of modeling data into the solution process, providing a decisive advantage on hard problems over more black-box type approaches.
- **Integrates with Xpress-Mosel advanced modeling language,** and also offers extensive utilities to interface with external user functions/simulators through the API (including calls to 3rd party libraries, Excel spreadsheets and macros, etc.).
- **Offers advanced mixed integer extensions** to solve nonlinear problems with integrality considerations.
- **Includes generic MIP search** utilizing the advanced MIP features of Xpress-Optimizer, and also features custom built nonlinear MIP heuristics for the quick identification of MIP feasible solutions.
- **Fits neatly into the Xpress product range** and leverages the strengths of the LP/MIP solvers within the Xpress product range.
- **Helps keep sub-model sizes in check** with the Xpress-Optimizer presolver, even for models with a high level of nonlinearity.
- **Has a proven history** of high level, dedicated, hands-on support.

» Pooling problems and Xpress-SLP

SLP as a technology is proven to be the algorithm of choice for large pooling problems:

- Bi- and tri-linear terms linearize well.
- SLP normally uses relatively few function evaluations: efficient use of expensive external simulation calls.
- Pooling problems are typically well-bounded by inherited model restrictions.
- Pooling problems often offer reasonable initial values.
- Advanced SLP techniques fit the process engineering problems very well, counteracting the lack of second order information, without the associated speed penalties:
  - Process information can be included: cascading (post-iteration projection of the linearized solution to the nonlinear surface).
  - Well-bounded models are robust against local perturbations of zero derivatives.
  - The linearized sub-models can take full advantage of linear presolve techniques.
  - Models are often large enough for second order methods to be prohibitively expensive.

» Xpress-SLP and special problem classes and modeling techniques

Convex quadratic objectives and convex quadratic constraints can be separately handled by Xpress-Optimizer, allowing for efficient extension of such problem classes with nonlinear information, while still being able to utilize the power of dedicated algorithms.

The integration with Xpress-Optimizer offers embedded SOS2 modeling for models where SOS2 constructs are beneficial for nonlinear expressions with very high curvature or non-continuity, but the size and complexity of the model prohibits a full level discretization.

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