

Optimization Techniques

Optimization technique is a powerful tool to obtain the desired design parameters and best set of operating conditions. This would guide the experimental work and reduce the risk and cost of design and operation. Optimization refers to finding the values of decision variables, which correspond to and provide the maximum or minimum of one or more desired objectives. The reliability of optimum solutions depends on the formulation of objective functions and selected optimization techniques. Optimization requires a mathematical model that describes and predicts the process behaviour. In complex non-linear processes, optimization search could help to estimate unknown parameters. Robust optimization could determine uncertainty variables in dynamic processes.

Optimization could be implemented as a tool to enable scale-up methodology and design of multiphase reactors and flow systems. Without optimization of design and operations, manufacturing and engineering activities will not be as efficient as they are now. Cautions regarding optimization algorithms can powerfully assist workers in operating and designing.

Optimization problems are usually divided into two major categories
“Linear and Non-Linear Programming”.

These programming techniques have three main components which need to be defined and they are
an objective function, decision variables, and constraints.

Difference between Linear Programming and Non – Linear Programming

Any relationship between two quantities that don't fit the definition of a linear relationship is called a nonlinear relationship. The easiest way to differentiate a linear relationship from a nonlinear relationship is by mapping them on a graph. Use the x-axis of the graph to represent one of the quantities and the y-axis to represent the other.

For example: If we plot “hours worked” on the x-axis and “money earned” on the y-axis with the help of a few known data points on the graph, such as one hour worked = \$10, two hours worked = \$20 and three hours worked = \$30. Since we can connect these points to form a straight line, this can be termed a linear relationship.

So why do we use non-linear programming when the linear approach is computationally less intensive and easy to understand?

Nonlinear programming is the "all of the above" of optimization models. Its name, after all, only indicates that the model is "not linear" — hardly a confining category. Nonlinear programming is

certainly a useful tool, since so many aspects of our world do not behave linearly. Doubling the dosage of a drug need not double its effectiveness. Assigning twice as many employees to a project does not guarantee that the project will be completed twice as fast. The NLP techniques are based on the reduced gradient method or use the penalty function optimization approach. In this method, the first partial derivatives of the equations (the reduced gradient) are used to choose a search direction in the iterative procedure. The merits of this method are it can be applied in a large-scale system while the drawbacks of this method are that some system components are not considered while computing.

Use Cases:

Nonlinear models arise often in science and engineering. They have been used, for example, to determine how to clean up impurities in underground fuel pipe systems. The model determines where to pump out contaminated fuel, and where to pump in clean fuel, so as to reduce the contamination to acceptable levels in either the least time or at the least cost. The constraints model the flow of fuel through the underground system and also specify limits on how much fuel can be pumped in and out.

Another application is in the design of buildings. Here the model determines which support beams to include in the layout, by determining what size it has to be, how thick it has to be, what is the distance between each of the beams, whether is there any specific design in laying them etc... so as to maximize the strength of the support beams thereby making the construction rock solid. The constraints in the model specify the locations and magnitudes of the loads that must be supported by the beams.

Although less common, nonlinear models can also arise in business applications, for example, in the management of investment portfolios. In this setting, the goal might be to determine a mix of investments so as to maximize return while minimizing risk. The nonlinearity in the model comes from taking risk into account.

Modelling of traffic also leads to nonlinearities, representing such notions as congestion and travel times. And gasoline blending models use nonlinear functions to represent volatility and octane-quality measures.

Another example of the use of non-linear programming is determined in defining the relationship between the value of a motorcycle and the amount of time you owned the motorcycle, or in the amount of time it takes to do a job in relation to the number of people there to help. If your boss raises your hourly rate to \$15 per hour when you work overtime, the relationship between your hours worked to your pay acquired might become nonlinear.

Reality:

Even though nonlinear models are capable of much greater realism and subtlety. Undoubtedly nonlinear programming has never been as popular as linear programming, Framing a linear program has never been difficult when compared with non-linear programming. A person should know how to frame the objective and constraints which is acceptable by the linear programming model, the rest can be done within a few clicks using the latest tech tools which are numerous available these days. “Standardisation towards specifying a model has been a tough thing when it comes to dealing with nonlinear models”.

This obstacle in the use of nonlinear programming is disappearing slowly. In the current era, it is much easier to express nonlinear models. Technology and Innovations are in boom these days but previously there was a larger difficulty with computer hardware and optimization software. Earlier, it was impractical to solve the optimization problems, either because the software could not reliably find a solution, or because the time required to solve the problems was too great.

Under certain conditions much stronger guarantees are possible. But it can be difficult to determine if a model satisfies these conditions and so they are not always of practical value. Some of these obstacles will never be overcome, but there is a danger of becoming obsessed with them. In truth, a great many problems can be solved using today's computers and software, and without a great deal of strain on the part of the modeller.

All In All, non-linear programming has recently gained importance due to the advancement in technology and innovations. It's not only the tech advancement but the emergence and upgradation of other optimization techniques such as simplex and dual methodology that have scaled up the implications of non-linear programming. ***“If there’s any given problem it is highly likely to be solved by deploying these methods, so we can also say that to any non-linear programming problem a mix of all the stratified approaches can help us solve it”.*** These advances have not only improved the performance and accuracy of nonlinear optimization algorithms but also started to scale up the usage of more of non-linear models to tackle real-life situations. These advancements have not only bought up the usage of non-linear programming techniques but also changed the life of engineers, doctors, investors and many people from the diversified sector.

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