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Chapter 1 : Multiple-criteria decision analysis - Wikipedia

Multiobjective Decision Analysis With Engineering and Business Applications attempts to cover the main multiobjective techniques both in their mathematical treatment and in their application to real-world problems.

Examples of applications[edit] Economics[edit] In economics , many problems involve multiple objectives along with constraints on what combinations of those objectives are attainable. This constraint allows more of one good to be purchased only at the sacrifice of consuming less of another good; therefore, the various objectives more consumption of each good is preferred are in conflict with each other. A common method for analyzing such a problem is to use a graph of indifference curves , representing preferences, and a budget constraint, representing the trade-offs that the consumer is faced with. Another example involves the production possibilities frontier , which specifies what combinations of various types of goods can be produced by a society with certain amounts of various resources. The frontier specifies the trade-offs that the society is faced with â€" if the society is fully utilizing its resources, more of one good can be produced only at the expense of producing less of another good. A society must then use some process to choose among the possibilities on the frontier. Macroeconomic policy -making is a context requiring multi-objective optimization. Typically a central bank must choose a stance for monetary policy that balances competing objectives â€" low inflation , low unemployment , low balance of trade deficit, etc. To do this, the central bank uses a model of the economy that quantitatively describes the various causal linkages in the economy; it simulates the model repeatedly under various possible stances of monetary policy, in order to obtain a menu of possible predicted outcomes for the various variables of interest. Then in principle it can use an aggregate objective function to rate the alternative sets of predicted outcomes, although in practice central banks use a non-quantitative, judgement-based, process for ranking the alternatives and making the policy choice. Finance[edit] In finance , a common problem is to choose a portfolio when there are two conflicting objectives â€" the desire to have the expected value of portfolio returns be as high as possible, and the desire to have risk , often measured by the standard deviation of portfolio returns, be as low as possible. The problem of optimizing a function of the expected value first moment and the standard deviation square root of the second central moment of portfolio return is called a two-moment decision model. Optimal control , Dynamic programming , and Linear-quadratic regulator In engineering and economics , many problems involve multiple objectives which are not describable as the-more-the-better or the-less-the-better; instead, there is an ideal target value for each objective, and the desire is to get as close as possible to the desired value of each objective. Often such problems are subject to linear equality constraints that prevent all objectives from being simultaneously perfectly met, especially when the number of controllable variables is less than the number of objectives and when the presence of random shocks generates uncertainty. Commonly a multi-objective quadratic objective function is used, with the cost associated with an objective rising quadratically with the distance of the objective from its ideal value. Before looking for optimal designs it is important to identify characteristics which contribute the most to the overall value of the design. Therefore, in practical applications, the performance of process and product design is often measured with respect to multiple objectives. These objectives typically are conflicting, i. For example, when designing a paper mill, one can seek to decrease the amount of capital invested in a paper mill and enhance the quality of paper simultaneously. If the design of a paper mill is defined by large storage volumes and paper quality is defined by quality parameters, then the problem of optimal design of a paper mill can include objectives such as: Here, maximum volume of towers are design variables. This example of optimal design of a paper mill is a simplification of the model used in. In , Fiandaca and Fraga used the multi-objective genetic algorithm MOGA to optimize the pressure swing adsorption process cyclic separation process. The design problem involved the dual maximization of nitrogen recovery and nitrogen purity. The results provided a good approximation of the Pareto frontier with acceptable trade-offs between the objectives. They tackled two case studies bi-objective and triple objective problems with nonlinear dynamic models and used a hybrid approach consisting of the weighted Tchebycheff and the Normal Boundary Intersection approach. The novel hybrid approach was able to construct a Pareto optimal set for the thermal processing of foods. The objective functions were methane conversion, carbon monoxide selectivity and hydrogen to carbon monoxide ratio. In , Abakarov et al proposed an alternative technique to solve multi-objective optimization problems arising in food engineering. The Analytic Hierarchy Process and Tabular Method were used simultaneously for choosing the best alternative among the computed subset of non-dominated solutions for osmotic dehydration processes. Their approach used a Mixed-Integer Linear Program to solve the optimization problem for a weighted sum of the two objectives to calculate a set of Pareto optimal solutions. The application of the approach to several manufacturing tasks showed improvements in at least one objective in most tasks and in both objectives in some of the processes. Each user has its own objective function that, for example, can represent some combination of the data rate, latency, and energy efficiency. These objectives are conflicting since the frequency resources are very scarce, thus there is a need for tight spatial frequency reuse which causes immense inter-user interference if not properly controlled. Multi-user MIMO techniques are nowadays used to reduce the interference by adaptive precoding. The network operator would like to both bring great coverage and high data rates, thus the operator would like to find a Pareto optimal solution that balance the total network data throughput and the user fairness in an appropriate subjective manner. Radio resource management is often solved by scalarization; that is, selection of a network utility function that tries to balance throughput and user fairness. The choice of utility function has a large impact on the computational complexity of the resulting single-objective optimization problem. The problem of optimization through the reconfiguration of a power distribution system, in terms of its definition, is a historical single objective problem with constraints. Since , when Merlin and Back [29] introduced the idea of distribution system reconfiguration for active power loss reduction, until nowadays, a lot of researchers have proposed diverse methods and algorithms to solve the reconfiguration problem as a single objective problem. Some authors have proposed Pareto optimality based approaches including active power losses and reliability indices as objectives. For this purpose, different artificial intelligence based methods have been used: Therefore, different researchers have defined the term "solving a multi-objective optimization problem" in various ways. This section summarizes some of them and the contexts in which they are used. Many methods convert the original problem with multiple objectives into a single-objective optimization problem. This is called a scalarized problem. If scalarization is done neatly,[clarification needed] Pareto optimality of the solutions obtained can be guaranteed. Solving a multi-objective optimization problem is sometimes understood as approximating or computing all or a representative set of Pareto optimal solutions. Here, a human decision maker DM plays an important role. The DM is expected to be an expert in the problem domain. The most preferred results can be found using different philosophies. Multi-objective optimization methods can be divided into four classes. In a priori methods, preference information is first asked from the DM and then a solution best satisfying these preferences is found. In a posteriori methods, a representative set of Pareto optimal solutions is first found and then the DM must choose one of them. In interactive methods, the decision maker is allowed to iteratively search for the most preferred solution. In each iteration of the interactive method, the DM is shown Pareto optimal solution s and describes how the solution s could be improved. The information given by the decision maker is then taken into account while generating new Pareto optimal solution s for the DM to study in the next iteration. More information and examples of different methods in the four classes are given in the following sections. Scalarizing[edit] Scalarizing a multi-objective optimization problem is an a priori method, which means formulating a single-objective optimization problem such that optimal solutions to the single-objective optimization problem are Pareto optimal solutions to the multi-objective optimization problem. A general formulation for a scalarization of a multiobjective optimization is thus min.

Chapter 2 : Multiobjective Stochastic Linear Programming: An Overview

DOWNLOAD MULTIOBJECTIVE DECISION ANALYSIS WITH ENGINEERING AND BUSINESS APPLICATIONS multiobjective decision analysis with pdf Multiple-criteria decision-making (MCDM) or multiple-criteria decision analysis (MCDA) is a sub-discipline of.

It is easier to detect the nondominated points corresponding to efficient solutions in the decision space in the criterion space. The north-east region of the feasible space constitutes the set of nondominated points for maximization problems. Generating nondominated solutions[edit] There are several ways to generate nondominated solutions. We will discuss two of these. The first approach can generate a special class of nondominated solutions whereas the second approach can generate any nondominated solution. These special efficient solutions appear at corner points of the set of available solutions. Efficient solutions that are not at corner points have special characteristics and this method is not capable of finding such points. Mathematically, we can represent this situation as max wT. Achievement scalarizing function Wierzbicki, [17] Figure 3. Projecting points onto the nondominated set with an Achievement Scalarizing Function Achievement scalarizing functions also combine multiple criteria into a single criterion by weighting them in a very special way. They create rectangular contours going away from a reference point towards the available efficient solutions. This special structure empower achievement scalarizing functions to reach any efficient solution. This is a powerful property that makes these functions very useful for MCDM problems. Any point supported or not can be reached. The second term in the objective function is required to avoid generating inefficient solutions. Figure 3 demonstrates how a feasible point, g1, and an infeasible point, g2, are projected onto the nondominated points, q1 and q2, respectively, along the direction w using an achievement scalarizing function. The dashed and solid contours correspond to the objective function contours with and without the second term of the objective function, respectively. For a bibliometric study showing their development over time, see Bragge, Korhonen, H. The purpose of vector maximization is to approximate the nondominated set; originally developed for Multiple Objective Linear Programming problems Evans and Steuer, ; [19] Yu and Zeleny, [20]. Phases of computation alternate with phases of decision-making Benayoun et al. The purpose is to set apriori target values for goals, and to minimize weighted deviations from these goals. Both importance weights as well as lexicographic pre-emptive weights have been used Charnes and Cooper, [25]. Fuzzy-set theorists Fuzzy sets were introduced by Zadeh [26] as an extension of the classical notion of sets. This idea is used in many MCDM algorithms to model and solve fuzzy problems. Multi-attribute utility theorists Multi-attribute utility or value functions are elicited and used to identify the most preferred alternative or to rank order the alternatives. Elaborate interview techniques, which exist for eliciting linear additive utility functions and multiplicative nonlinear utility functions, are used Keeney and Raiffa, [27]. The method was first proposed by Bernard Roy Roy, [28]. Evolutionary multiobjective optimization school EMO EMO algorithms start with an initial population, and update it by using processes designed to mimic natural survival-of-the-fittest principles and genetic variation operators to improve the average population from one generation to the next. The goal is to converge to a population of solutions which represent the nondominated set Schaffer, ; [29] Srinivas and Deb, [30]. Then the decision-maker evaluates the relative importance of its various elements by pairwise comparisons. The AHP converts these evaluations to numerical values weights or priorities , which are used to calculate a score for each alternative Saaty, [32]. A consistency index measures the extent to which the decision-maker has been consistent in her responses. AHP is one of the more controversial techniques listed here, with some researchers in the MCDA community believing it to be flawed. The underlying mathematics is also more complicated, though it has gained some popularity as a result of commercially available software.

Chapter 3 : Multi-objective optimization - Wikipedia

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