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Series Title	International Series in Operations Research & Management Science
Book Title	Algorithmic Decision Making with Python Resources
Book Sub-title	From Multicriteria Performance Records to Decision Algorithms via Bipolar-Valued Outranking Digraphs
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Part I

Part Title	Introduction to the Digraph3 Python Resources
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Chapter Title	Working with the DIGRAPH3 Python Resources	
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Abstract	The chapter is devoted to a first contact with the DIGRAPH3 Python resources. Following the installation instructions, we list the main Python modules with their purpose and eventually illustrate in a first Python terminal session how to generate, save, and inspect a random crisp digraph.	

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Chapter Title	Working with Bipolar-Valued Digraphs	
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Abstract	The chapter introduces bipolar-valued digraphs, the fundamental root type of all the specialised digraphs implemented in the DIGRAPH3 modules. With the help of a randomly valued digraph, we illustrate some basic digraph manipulation methods, like drawing the digraph, dividing the digraph into its asymmetric and symmetric parts, separating the border from the inner part, computing associated dual, converse and codual digraphs, and operating symmetric and transitive closures.	

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Chapter Title	Working with Outranking Digraphs	
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Abstract	<p>In this chapter, we introduce the main formal object of this book, namely the bipolar-valued outranking digraph. With a randomly generated multiple-criteria performance tableau, we construct the corresponding bipolar-valued outranking relation from pairwise comparisons. The resulting bipolar-valued outranking characteristics may be recoded. Finally, the codual outranking digraph gives us the associated strict outranking relation.</p>	

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Part II

Part Title	Evaluation Models and Decision Algorithms
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Chapter Title	Building a Best Choice Recommendation	
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Abstract	<p>This chapter presents the RUBIS best choice recommender system. Our approach is illustrated with a best office location selection problem. We show how to explore the given performance tableau and compute the corresponding outranking digraph. After presenting the pragmatic principles that govern our best choice recommendation algorithm we solve the best office location choice problem.</p>	

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Chapter Title	How to Create a New Multiple-Criteria Performance Tableau	
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Abstract	The chapter illustrates a way of creating a new PerformanceTableau instance by editing a given template with five decision alternatives, three decision objectives, and six performance criteria. We discuss in detail editing the decision alternatives, the decision objectives, the family of performance criteria, and finally, the evaluations of the decision alternatives on the performance criteria.	

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Chapter Title	Generating Random Performance Tableaux	
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Abstract	The chapter describes the DIGRAPH3 resources for generating random multiple-criteria performance tableaux like a <i>Cost-Benefit</i> tableau, a three Objectives— <i>economic</i> , <i>societal</i> , and <i>environmental</i> —tableau, and an <i>academic</i> performance tableau.	

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Chapter Title	Who Wins the Election?	
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Abstract	<p>This chapter is more specifically devoted to handling linear voting profiles and computing the winner of such election results. By following CONDORCET's recipe, we consider pairwise comparisons of election candidates and balance the number of times the first beats the second against the number of times the second beats the first. Thus we obtain the majority margins digraph, in fact a bipolar-valued digraph. When the voters express contradictory linear voting profiles one naturally observes cyclic social preferences without seeing any paradox in this situation. Finally we present a more politically realistic generator for random linear voting profiles which takes into account pre-election polls.</p>	

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Chapter Title	Ranking with Multiple Incommensurable Criteria	
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Abstract	The DIGRAPH3 python resources provide several algorithms for solving the multiple incommensurable criteria ranking problem via bipolar-valued outranking digraphs. The COPELAND, NETFLOWS, KEMENY, SLATER, KOHLER, and the RANKEDPAIRS ranking rules are introduced and illustrated with a random outranking digraph.	

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Chapter Title	Rating by Sorting into Relative Performance Quantiles	
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Abstract	In this chapter, we apply order statistics for sorting a set X of n potential decision alternatives, evaluated on m incommensurable performance criteria, into q quantile equivalence classes. The sorting algorithm is based on pairwise outranking characteristics involving the quantile class limits observed on each criterion. Thus we may implement a weak ordering algorithm of complexity $O(nmq)$.	

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Chapter Title	Rating-by-Ranking with Learned Performance Quantile Norms	
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Abstract	<p>We address in this chapter the problem of rating multiple-criteria performances of a set of potential decision alternatives with respect to performance quantiles learned from historical performance data gathered from similar decision alternatives observed in the past. We show how to learn performance quantiles from such historical performance tableaux. New performance records may now be rated with respect to these quantile norms.</p>	

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Chapter Title	HPC Ranking of Big Performance Tableaux	
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Abstract	<p>The sparse outranking digraph, introduced in Chap. 9, is suitable for tackling the ranking of big multiple-criteria performance tableaux with thousands or millions of records. To effectively compute rankings from performance tableaux of these sizes, we propose in this chapter a collection of C-compiled and optimised DIGRAPH3 modules that may be run on HPC equipment as available, for instance, at the University of Luxembourg.</p>	

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Part III

Part Title	Evaluation and Decision Case Studies
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Chapter Title	Alice's Best Choice: A Selection Case Study	
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Abstract	The chapter presents a case study concerning the building of a best choice recommendation for Alice, a German student who wants some advice concerning the choice of her future University studies. We present Alice's performance tableau—potential foreign language study programs, her decision objectives, performance criteria and performance evaluations—and build a best choice recommendation for her. A thorough robustness analysis confirms a very best choice.	

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Chapter Title	The Best Academic Computer Science Depts: A Ranking Case Study	
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Abstract	<p>In this case study, we are solving with our DIGRAPH3 resources a ranking decision problem based on published data from the <i>Times Higher Education</i> (THE) <i>World University Rankings</i> 2016 by <i>Computer Science</i> (CS) subject. Several hundred academic CS Departments, from all over the world, were ranked that year following an overall numerical score based on the weighted average of five performance criteria: <i>Teaching</i> (the learning environment, 30%), <i>Research</i> (volume, income and reputation, 30%), <i>Citations</i> (research influence, 27.5%), <i>International outlook</i> (staff, students, and research, 7.5%), and <i>Industry income</i> (innovation, 5%). To illustrate our DIGRAPH3 programming resources, we shall first have a look into the THE multiple-criteria ranking data with short Python scripts. In a second section, we shall relax the commensurability hypothesis of the ranking criteria and show how to similarly rank with multiple incommensurable performance criteria of solely ordinal significance. A third section is finally devoted to introduce quality measures for qualifying ranking results.</p>	

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Chapter Title	The Best Students, Where Do They Study? A Rating Case Study	
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Abstract	<p>In 2004, the German magazine <i>Der Spiegel</i>, with the help of <i>McKinsey & Company</i> and <i>AOL</i>, conducted an extensive online survey, assessing the apparent quality of German University students. The eventually published results by the <i>Spiegel</i> magazine concerned nearly 50,000 students, enrolled in one of fifteen popular academic subjects, like <i>German Studies</i>, <i>Life Sciences</i>, <i>Psychology</i>, <i>Law</i> or <i>CS</i>. Based on this published data, we present and discuss in this chapter, how to <i>rate</i> with the help of our DIGRAPH3 software resources the apparent global <i>enrolment quality</i> of new performance records.</p>	

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Chapter Title	Exercises	
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Abstract	In this chapter, we propose a series of decision problems of various difficulties which may serve as exercises and exam questions for an Algorithmic Decision Theory or Multiple-Criteria Decision Analysis course. They cover <i>selection</i> , <i>ranking</i> , and <i>rating</i> decision problems.	

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Part IV

Part Title	Advanced Topics
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Chapter Title	On Measuring the Fitness of a Multiple-Criteria Ranking	
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Abstract	Starting from a motivating decision problem about how to list, from the best to the worst, a set of movies that are star-rated by journalists and movie critics, the chapter shows that KENDALL's ordinal correlation index tau can be extended to a bipolar-valued relational equivalence measure of bipolar-valued digraphs. This finding gives way, on the one hand, to measure the fitness and fairness of multiple-criteria ranking rules. On the other hand, it provides a tool for illustrating preference divergences between decision objectives and criteria.	

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Chapter Title	On Computing Digraph Kernels	
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Abstract	<p>We illustrate in this chapter, first, the concept of graph kernel, i.e. maximal independent set of vertices. In non-symmetric digraphs, the kernel concept becomes richer and separates into initial and terminal kernels. In, furthermore, lateralised outranking digraphs, initial and terminal kernels become separate and may deliver suitable first and, respectively, last choice recommendations. After commenting the tractability of kernel computations, we close the chapter with the solving of bipolar-valued kernel equation systems.</p>	

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Chapter Title	On Confident Outrankings with Uncertain Criteria Significance Weights	
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Abstract	<p>When modelling preferences following the outranking approach, the signs of the majority margins do sharply distribute validation and invalidation of pairwise outranking situations. How can we be confident in the resulting outranking digraph, when we acknowledge the usual imprecise knowledge of criteria significance weights coupled with small majority margins? In this chapter we propose to link the qualifying significance majority with a required $\alpha\%$-confidence level. We model therefore the significance weights as random variables following more or less widespread distributions around an average significance value that corresponds to the given deterministic weight. As the bipolar-valued random credibility of an outranking statement hence results from the simple sum of positive or negative independent random variables, we may apply the Central Limit Theorem (CLT) for computing the bipolar likelihood that the expected majority margin will indeed be positive and, respectively, negative.</p>	

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Chapter Title	Robustness Analysis of Outranking Digraphs	
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Abstract	<p>The required cardinal significance weights of the performance criteria represent the ‘<i>Achilles</i>’ heel of the outranking approach. Rarely will indeed a decision maker be cognitively competent for suggesting precise decimal-valued criteria significance weights. More often, the decision problem will involve more or less equally important decision objectives with more or less equi-significant criteria per objective. In this chapter, we study the robustness of the outranking digraph when the criteria significance weights faithfully indicate solely an order of importance.</p>	

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Chapter Title	Tempering Plurality Tyranny Effects in Social Choice	
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Abstract	<p>In a <i>social choice</i> context, where decision objectives would match different political parties, Pareto efficient choice recommendations represent in fact <i>multipartisan</i> social choices that may judiciously deliver the primary selection in a two-stage election system. Our bipolar-valued outranking model is based on approvals-disapprovals of ‘<i>at least as well evaluated as</i>’ statements. A similar approach is put into practice with approval–disapproval voting systems. When converting such approval–disapproval voting ballots into corresponding performance records, we obtain a $(-1, 0, 1)$-valued evaluative voting system. We eventually show that in such an approval–disapproval voting system, the winner tends to be among the more or less multipartisan candidates.</p>	

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Part V

Part Title	Working with Undirected Graphs
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Chapter Title	Bipolar-Valued Undirected Graphs	
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Abstract	The chapter introduces bipolar-valued undirected graphs and illustrates several special graph models and algorithms like Q-coloring, MIS and clique enumeration, line graphs and maximal matchings, grid graphs, and n -cycle graphs with their non-isomorphic maximal independent sets of vertices.	

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Chapter Title	On Tree Graphs and Graph Forests	
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Abstract	The chapter specifically addresses working with tree graphs and graph forests. We illustrate how to generate and recognise random tree graphs and how to compute the centres of a tree and draw a rooted and oriented tree. Finally, algorithms for computing spanning trees and forests are presented.	

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Chapter Title	About Split, Comparability, Interval, and Permutation Graphs	
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Abstract	<p>The last chapter of this book eventually presents some famous classes of perfect graphs, namely comparability, interval, permutation, and split graphs. We first present an example of a graph which is at the same time a triangulated, a comparability, a split, and a permutation graph. The importance to be an interval is illustrated with BERGE's mystery story. We discuss furthermore the generation of permutation graphs and close with how to recognise that a given graph is in fact a permutation graph.</p>	