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The Industrial Engineering (IE) Department (http://www.ie.metu.edu.tr/) of Middle East Technical University (METU) has approximately 20 full-time faculty members, 600 undergraduate students, 200 M.S. students, and 15 Ph. D. students. Faculty members and students conduct research in a wide spectrum, covering many areas of IE. The research constitutes methodological developments as well as application projects for the public and private sectors. Every year, teams of senior-level students undertake some 20-25 Systems Design projects for different organizations under the supervision of faculty members. Additionally, faculty and graduate students are regularly involved in projects and consulting funded by various organizations.

I will briefly review the Multiple Criteria Decision Making (MCDM) – related research we have been conducting in recent years. Some of this research is in the form of developing approaches for the general MCDM area. Some address MCDM issues in different functional areas. Some research consider multiple criteria explicitly in real life applications and some provide decision makers (DMs) an indirect support on potentially interesting solutions.

The 15th International Conference on MCDM was organized at METU in 2000 and Murat Köksalan chaired the organizing committee. Many presented research papers were submitted after the conference and those that survived a thorough review process were collected in the Proceedings of the conference.[29]

I will summarize our recent research efforts under several headings.

Multiobjective Combinatorial Optimization (MOCO)

MOCO is an exciting research area that has been steadily growing in recent years. The problems in this area are computationally difficult and modern heuristic search have been widely used. Evolutionary methods have been particularly useful. We have been involved in MOCO research. The literature is flooded with approaches that try to generate the efficient frontier for bi-criteria problems. While we also develop approaches for approximating the efficient frontier of a general MOCO problem[38], we find it important to converge towards the most preferred solution of the DM through an interactive approach[36,37] or to generate the efficient solutions in the preferred regions of the solution space.[23]

Many scheduling problems fall under the category of MOCO. We have been studying scheduling problems extensively. Many of these are bicriteria problems. Some studies try to generate the efficient frontier while others try to converge the most preferred solution under certain assumptions. [1,2,3,4,13,22,33,39] Facility location problems are another class of MOCO problems we address.[30]

Ranking and Sorting

Ranking of alternatives based on multiple criteria has many applications in real life. We developed several approaches in this area and applied some of them.[10,12,27] A closely related problem is the so called sorting problem where alternatives are categorized into a number of preference-ordered classes. We have been doing research in this area as well. In addition to recent publications[7,20,28,40], we have several ongoing projects. Performance evaluation is another closely related problem we have considered.[34]

General MCDM

We have been studying interactive approaches for a long time. We may cite two recent approaches for finding the most preferred solutions of DMs for continuous solution spaces[21] and for discrete alternative sets.[26] Searching the discrete alternative set is computationally easier. We developed an approach that tries to obtain a discrete set of alternatives that represents the underlying continuous solution space well.[14]

We also worked on outranking-based models and behavioral aspects of MCDM.[15,16,31,32]

We have two overview papers intended as introductory material to those who want to get acquainted with MCDM.[11,18]

Applications

In many of our work with the industry we consider multiple criteria. In some, we explicitly evaluate the criteria and in others we explore the solution space in such a way to facilitate DMs to consider other criteria before making the final decision.[5,6,8,9,17,35] We regularly prepare teaching material based on our practical experiences from the application projects. These also incorporate multiple criteria either directly or indirectly. Two case studies we prepared won the first prizes in the 2002 and 2006 INFORMS Case Competitions.[19,25]

An important application area for MCDM is product and process design. Values of design parameters affect various performance measures and the relations are highly nonlinear. In the literature various aggregation functions have been used to determine the values of design parameters. We proposed an interactive approach that progressively incorporates the DM's preferences into the solution process of determining the design parameters.[24] Our approach conveys the past developments in the MCDM area into product and process design.

References

1. Alagöz, O. and M. Azizoğlu, "Rescheduling of Identical Parallel Machines under Machine Eligibility Constraints", *European Journal of Operational Research*, 149, 523-532, 2003.

2. Azizoğlu, M. and O. Alagöz, "Parallel Machine Rescheduling with Machine Disruptions," *IIE Transactions*, 37, 1113-1118, 2005.

3. Azizoğlu, M., M. Köksalan and S. Kondakcı, "Single Machine Scheduling with Maximum Earliness and Number Tardy: inserted idle time allowed case," *Journal of Operational Research Society*, 54, 661-664, 2003.

4. Azizoğlu, M., S. Kondakcı and M. Köksalan, "Single Machine Scheduling with Maximum Earliness and Number Tardy: no inserted idle time case," *Computers and Industrial Engineering*, 45, 257-268, 2003.

5. Batun, S., E. S. Bozgüney, Z. Kirkizoğlu, Ş. Sezginer, and E. Sönmez, "Alignment of Pfizer Turkey's Sales Territories," *Systems Design Project Report*, Department of Industrial Engineering, METU, Ankara, Turkey, 2004.

6. Balıbek, E. and M. Köksalan, "A Multi-Objective Multi-Period Stochastic Programming Model for Public Debt Management," under review, 2006.

7. Bilgin, S., M. Köksalan, V. Mousseau, and Ö. Özpeynirci, "A New Outranking-based Approach for Assigning Alternatives to Ordered Classes," under review.

8. Bilgin, S., M. Köksalan, and H. Süral, "Reorganization of the Supply Chain of Beer and Malt," (made for Efes Pilsen - a private beer brewer company), *Final Report*, July 2005 (in Turkish).

9. Büyükburç, A. and Köksal, G., 2005, "An Attempt to Minimize the Cost of Extracting Lithium from Boron Clays Through Robust Process Design", *Clays and Clay Minerals*, 53(3), 301-309.

10. Eryılmaz U. and E. Karasakal, "A Hybrid Ranking Method Based on Data Envelopment Analysis and Outranking Methods," In Aladağ Zerrin and Nilgün Fığlalı (eds.): Proceedings of the 26th Operations Research and Industrial Engineering National Conference, 498-501, July 2006 (in Turkish).

11. Karasakal E. and W. Michalowski, "Incorporating Wealth Information into a Multiple Criteria Decision Making Model," *European Journal of Operational Research*, 150 (1): 204-219, October 2003.

12. Karasakal E. and M. Köksalan, "A Simulated Annealing Approach to the Bicriteria Scheduling Problems on a Single Machine," *Journal of Heuristics*, 6 (3): 311-327, August 2000.

13. Karasakal E., O. Karasakal and S. Akgün, "Project Ranking with Interdependent Criteria using Prospect Theory," In Durmusoglu M. Bülent and Cengiz Kahraman (eds.): Proceedings of the 35th International Conference on Computers and Industrial Engineering, Vol:1, 1081-1084, June 2005.

14. E. Karasakal and G. Özerol, "Incorporating Prospect Theory into an Outranking Method for MCDM under Imprecise Information," *Technical Report 06-06*, Department of Industrial Engineering, METU, Ankara, Turkey, September 2006.

15. Karasakal E. and O. Karasakal, "Multiple Criteria Decision Making Methods," Maritimes Regional Advisory Process Working Paper 2001/46, Department of Fisheries and Oceans, Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada, June 2001.

16. Karasakal E. K. and M. Köksalan, "Generating a Representative Subset of the Efficient Frontier in Multiple Criteria Decision Making," *Working Paper 01-20*, Faculty of Administration, University of Ottawa, Ottawa, Ontario, Canada, May 2001.

17. Köksal, G. and B. Nalçacı, "The relative efficiency of departments at a Turkish engineering college: a data envelopment analysis," *Higher Education*, 51(3), 173-189. (2006).

18. Köksalan, M., "Multiple Criteria Decision Making," in *Operations Research*, A Volume in Honour of Professor Halim Doğrusöz, N. Erkip and M. Köksalan (eds.), 2002 (in Turkish).

19. Köksalan, M. and S. Batun, "Assigning Regions to Sales Representatives at Pfizer Turkey," Won the first prize at the 7th Annual INFORMS Case Competition, 2006.

20. Köksalan, M., T. Büyükbaşaran, Ö. Özpeynirci, J. Wallenius, "An Approach to Ranking with an Application to MBA Programs," *Technical Report 06-01*, Department of Industrial Engineering, METU, Ankara, Turkey, 2006.

21. Köksalan, M. and E. Karasakal, "An Interactive Approach for Multiobjective Decision Making," *Journal of Operational Research Society*, 57, 532–540, 2006.

22. Köksalan, M. and A. B. Keha, "Using Genetic Algorithms for Single-Machine Bicriteria Scheduling Problems," *European J. Oper. Res.* Vol. 145, 543-556, 2003.

23. Köksalan, M. and S. Pamuk Phelps, "An Evolutionary Metaheuristic for Approximating Preference-Nondominated Solutions," *INFORMS Journal on Computing*, forthcoming.

24. Köksalan, M. and R. D. Plante, "Interactive Multi-Criteria Optimization for Multiple Response Product and Process Design," *Manufacturing and Service Operations Management*, Vol. 5, No. 4, 334-347, 2003.

25. Köksalan, M. and Salman, S. "Beer in the Classroom: A Case Study of Location and Distribution Decisions," *INFORMS Transactions on Education*, September 2003 (Won the first prize at the 3rd Annual INFORMS Case Competition, 2002).

26. Köksalan, M. and O. Rizi, "A Visual Interactive Approach for Multiple Criteria Decision Making with Monotone Utility Functions," *Journal of Operational Research Society*, Vol. 52, 665-672, 2001.

27. Köksalan, M. and C. Tuncer, "A DEA-Based Approach to Ranking Multi-Criteria Alternatives," under review.

28. Köksalan, M. and C. Ulu, "An Interactive Procedure for Placing Alternatives in Preference Classes," *European J. Oper. Res.* Vol 144, 429-439, 2003.

29. Köksalan, M. and S. Zionts (editors), Multiple Criteria Decision Making in the New Millennium, Springer Verlag, 2001.

30. Nadirler D. and E. Karasakal, "Mixed Integer Programming Based Solution Procedures for Single Facility Location with Maximin of Rectilinear Distance," *Technical Report 06-03*, Department of Industrial Engineering, METU, Ankara, Turkey, September 2006.

31. Özerol, G. and E. Karasakal, "Interactive Outranking Approaches for Multicriteria Decision Making Problems with Imprecise Information," *Technical Report 06-04*, Department of Industrial Engineering, METU, Ankara, Turkey, September 2006.

32. Özerol, G. and E. Karasakal, "An Exposition of Regret Attitude of Decision Maker in Outranking Methods," *Technical Report 06-05*, Department of Industrial Engineering, METU, Ankara, Turkey, September 2006.

33. Özlen, M. and M. Azizoğlu, "Rescheduling Unrelated Parallel Machines with Total Flow Time and Weighted Number of Reassigned Jobs Criteria," under review.

34. Özpeynirci, Ö. and M. Köksalan, "Performance Evaluation Using Data Envelopment Analysis in the Presence of Time Lags," under review.

35. Pamuk, S., M. Köksalan, and R. Güllü, "Analysis of the Product Delivery System of a Beer Producer in Ankara," *Journal of Operational Research Society*, Vol. 55, 1137-1144, 2004.

36. Pamuk, S. and M. Köksalan, "An Interactive Genetic Algorithm Applied to the Multiobjective Knapsack Problem," in *Multiple Criteria Decision Making in the New Millennium*, Proceedings of the 15th International Conference on Multiple Criteria Decision Making, M. Köksalan and S. Zionts (Eds.), Springer Verlag, pp. 265-272, 2001.

37. Phelps Pamuk, S. and Köksalan, M. "An Interactive Evolutionary Metaheuristic for Multiobjective Combinatorial Optimization," *Management Science*, Vol. 49, No. 12, 1726-1738, 2003.

38. Soylu, B. and M. Köksalan, "A Favorable Weight Based Evolutionary Algorithm for Multiple Criteria Problems," under review.

39. Toktaş, B., M. Azizoğlu and S. Kondakcı, "Flowshop Scheduling with Two Criteria: Maximum Earliness and Makespan" *European Journal of Operational Research*, 157, 286-295, 2004.

40. Ulu, C. and M. Köksalan, "An Interactive Procedure for Selecting Acceptable Alternatives in the Presence of Multiple Criteria," *Naval Research Logistics*, Vol. 48, pp. 592-606, 2001.