Summary of the Dagstuhl Seminar 04461 entitled Practical Approaches to Multi-Criterion Optimization held during 8–12, November, 2004

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1 Motivation and Introduction

As the name suggests, multi-criterion optimization involves optimization in the presence of more than one (conflicting) criteria. Multi-criterion optimization problems arise in a variety of real-world applications and the need for efficient and reliable solution methods is increasing. The main difference between single and multi-criterion optimization is that in case of the latter, there is usually no single optimal solution, but a set of equally good alternatives with different trade-offs, also known as Pareto-optimal solutions. In the absence of any other information, none of these solutions can be said to be better than the other. Usually, a decision maker is needed to provide additional preference information and to identify the most satisfactory solution. Depending on the paradigm used, such knowledge may be introduced before, during, or after the optimization process. Multi-criterion optimization thus has to combine two aspects: optimization and decision support.

So far, there have existed basically two different approaches with corresponding fields of research: the classical approach and the evolutionary algorithm approach. The classical approach has a comparatively long history and subsumes a number of different algorithms, mostly developed by researchers from mathematics and operations research. These algorithms usually generate one solution and then adjust and re-optimize it according to the user's preferences. If they generate a set of alternatives, a small set of alternatives are usually generated sequentially. Many classical methods convert the problem with multiple criteria into one or a series of single criterion problems. On the other hand, evolutionary multi-objective optimization (EMO) is a relatively young research area, and is mostly grounded in computer science and engineering. Since evolutionary algorithms maintain a population of solutions throughout the optimization process, they are naturally suited to search for a large, representative

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set of Pareto-optimal solutions in parallel. In most cases, these solutions are created without the intervention of any decision-maker. Only after the optimization process has been completed, the decision maker chooses from the set of alternative solutions.

Both classical and evolutionary approaches have their merits and demerits, and both fields have become important and emerging topics in the area of informatics and operations research. But while both fields have resulted in a number of efficient algorithms and successful applications published in dedicated books and major international journals and conferences (some references are [1–8]), interactions among the fields are rarely found.

A major purpose of this seminar therefore was to bring together leading experts from both fields for discussions on the current state-of-the-art methodologies and common interests.

2 Proceeding of the Seminar

The seminar was participated by 39 persons from 15 countries. It consisted of two tutorials, 27 talks, group discussions on three selected topics, a panel discussion, and software demonstrations.

Because the aforementioned two fields of research in multi-criterion optimization have been more or less separated from each other so far, the seminar started with two introductory tutorials to get each group a basic introduction to the respective other field. The tutorial on classical multi-criterion optimization was delivered by Kaisa Miettinen, the one on evolutionary multi-criterion optimization was delivered by Kalyanmoy Deb. Besides providing an overview of the respective fields of research and their current state-of-the-art methodologies, also future directions were discussed.

Throughout the week, participants gave talks on their individual research areas. There was a good mix of theoretical and practical topics, classical and evolutionary methods, and current and traditional methodologies. Besides the seminar presentation, there was a panel discussion organized by industrial participants to discuss the experience of software industries and application industries in using existing multi-criterion optimization methods in practical problem solving.

To foster the interactions among the two groups further and to allow a free unstructured discussion on emerging issues, about 3 hours were set aside for discussions on specific topics in smaller groups. The topics were selected by the participants such that they attracted participants

from both research groups. The selected topics were: Integrating user preferences, differences between classical and evolutionary approaches, and performance measurements. On Thursday, group leaders from each group presented a summary of the discussions to the general audience.

On Wednesday afternoon, the traditional hiking tour took place. The evenings were occupied with software presentations (Tuesday), a panel discussion (Wednesday), and a wine and cheese party (Thursday). For a better feel of the field, organizers arranged to collect and bring about 20 seminal books on the topic and books were displayed in the seminar room for the entire five days of the seminar. Of course, Dagstuhl's excellent library gave additional opportunities for reading.

3 Achievements of the Seminar / Feedback from Participants

The Seminar was clearly unique because it brought together scholars from the two sides of the rapidly growing area of multi-criterion optimization. Prior to the Seminar, people from the two sides, coming from different disciplines, hardly knew each other. However, as a result of the Seminar, it is clear that the two sides are now to be considered as comprising the whole of the field of multi-criterion optimization in the most modern interpretation of the term.

The discussions were lively and certainly helped to clarify the terminology used in different groups, which should make reading and understanding each other's research paper easier. Active collaboration between the fields was fostered. As one example, some participants, from both classical and EMO fields even made a head-start to work on a joint project of outlining an interactive multi-criterion optimization method bringing together and hybridizing ideas utilized in the two fields.

At the closing session, the organizers collected feedback about the seminar, which is summarized in the following. All participants found the seminar very successful and were very excited about the idea of bringing together researchers from the two fields of multi-criterion optimization and expressed their interest in participating in such a seminar again. Participants appreciated the excellent opportunity to get to learn about the state-of-the-art, to discuss, to interact, to exchange ideas and to get new ideas. They liked the possibility of meeting many experts and asking them directly on their subjects of interests. It was great how people from classical and EMO fields were able to establish collaborative arrangements that would not have been possible without such a seminar. They also

liked the idea of working groups and their results. It was emphasized that we should cooperate as much as possible including newsgroups, a paper repository, and website. Some participants even said that this seminar was the most fruitful meeting for a decade for them! Finally, the participants mentioned the Dagstuhl atmosphere as a really significant ingredient in the success of the seminar.

4 Future Dagstuhl Seminar on the Topic

Since all participants agreed about the success of the seminar and the importance of bringing together the different research groups, and in order to keep the momentum, it was agreed to try to arrange such a seminar again in about two years time. As special themes for the next Dagstuhl seminar, the following ideas were raised:

1. *Hybridization or integration of classical and evolutionary methods* (to solve real-world problems) as well as the future of multi-criterion optimization (including hybrids). In other words, less specialized talks and more talks on how one could develop good (hybrid) algorithms.
2. *More focus on practical applications.* Particularly, focusing on the fact that Pareto-optimal solutions are not always optimal for decision makers but there is more to it than simply finding the optimal solutions.
3. *Visualization techniques*, particularly for problems having a large number of objectives. In this regard, handling fuzzy and uncertain data can also be discussed.

Furthermore, it was suggested to reduce the number of talks and to reserve more time for discussion groups.

References

1. C. A. C. Coello, D. A. VanVeldhuizen, and G. Lamont. *Evolutionary Algorithms for Solving Multi-Objective Problems.* Boston, MA: Kluwer Academic Publishers, 2002.
2. K. Deb. *Multi-objective optimization using evolutionary algorithms.* Chichester, UK: Wiley, 2001.
3. M. Ehrgott. *Multicriteria Optimization.* Berlin: Springer, 2000.
4. C. Fonseca, P. Fleming, E. Zitzler, K. Deb, and L. Thiele, editors. *Proceedings of the Second Evolutionary Multi-Criterion Optimization (EMO-03) Conference (Lecture Notes in Computer Science (LNCS) 2632).* Heidelberg: Springer, 2003.
5. K. Miettinen. *Nonlinear Multiobjective Optimization.* Kluwer, Boston, 1999.
6. A. Osyczka. *Evolutionary algorithms for single and multicriteria design optimization.* Heidelberg: Physica-Verlag, 2002.

7. R. E. Steuer. *Multiple Criteria Optimization: Theory, Computation and Application.* New York: Wiley, 1986.
8. E. Zitzler, K. Deb, L. Thiele, C. A. C. Coello, and D. Corne, editors. *Proceedings of the First Evolutionary Multi-Criterion Optimization (EMO-01) Conference (Lecture Notes in Computer Science (LNCS) 1993).* Heidelberg: Springer, 2001.