EURO Summer Institute 2010

Nonlinear Methods in Combinatorial Optimization

Klagenfurt, Aug. 20 - Sept. 3, 2010

Final Report

Participants and Senior Lecturers in the Carinthian Alps

1 General information

Scientific Committee:

- Miguel Anjos (University of Waterloo, Canada)
- Etienne DeKlerk (Tilburg University, The Netherlands)
- Christoph Helmberg (Technische Universität Chemnitz, Germany)
- Florian Jarre (Universität Düsseldorf, Germany)
- Veronical Piccialli (Università degli Studi Roma Tor Vergata, Italy)
- Franz Rendl (Alpen-Adria Universität Klagenfurt, Austria) (chair)

Local Organizing Committee:

- Philipp Hungerländer
- Franz Rendl (chair)
- Angelika Wiegele
- Anita Wachter (secretarial support)
- Andreas Starchel (technical support)

Sponsors

- EURO, the association of European Operational Research Societies
- ÖGOR, the Austrian Operations Research Society
- Alpen-Adria Universität Klagenfurt, Austria
- Privatstiftung der Kärntner Sparkasse
- Institut für Mathematik der Alpen-Adria Universität Klagenfurt

2 List of Participants

Out of the 17 participants, nominated from the respective local Operations Research societies, there were four female participants.

1. Boussaid, Ilhem, Algeria (ilhem_boussaid@yahoo.fr ; ilhem.boussaid@univ-paris12.fr)
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7. Hungerländer, Philipp, Austria (philipp.hungerlaender@uni-klu.ac.at)
8. Kleefisch, Thomas, Germany (kleefisch@zpr.uni-koeln.de)
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14. Plümpe, Daniel, Germany (pluempe@informatik.uni-koeln.de)
15. Schmutzer, Andreas, Germany (schmutzer@informatik.uni-koeln.de)
16. Vieira, Manuel, Portugal (mvcv@fct.unl.pt)
17. Yepremyan, Liana, Armenia (liana.yepremyan@viragelogic.com)

3 Scientific Overview

3.1 Aims and scope

Nonlinear methods such as semidefinite optimization or eigenvalue optimization have been successfully applied in the last decade to deal with NP-hard combinatorial optimization problems. A prominent example is furnished by the theta function, introduced by Lovasz (1979), which is a tractable graph parameter separating the clique number from the chromatic number. It can be formulated either in terms of eigenvalue optimization or as the optimal solution of a semidefinite program. Consequently, techniques from convex optimization are increasingly used in combinatorial optimization. On the algorithmic side, this is mostly due to the generalization of the interior-point methodology from linear to semidefinite programming. Even though the interior-point machinery carries over nicely from linear to semidefinite optimization, the computational overhead due to dense linear algebra operations makes it necessary to explore algorithmic alternatives to interior-point methods.

The hyperplane rounding idea of Goemans and Williamson has turned out to be a strong theoretical tool in the approximation analysis of algorithms, opening up a new area of research in theoretical computer science. Finally, the new relaxations can also be used to solve problems to optimality. This requires algorithmic engineering to combine (nonlinear) bounding techniques with limited enumeration. It is the purpose of the summer institute to focus on recent developments in this area. The following topics are of major interest to the EURO Summer Institute.

- Investigation of new relaxations for NP-hard problems,
- Algorithms for large scale semidefinite programs and related other conical relaxations of combinatorial optimization problems,
- Investigation of rounding heuristics, based on these relaxations,
- Exact solution methods, using semidefinite relaxations in combination with enumeration techniques

3.2 Tutorial Lectures

Each of the senior lecturers gave four (or more) tutorial lectures, whos contents are summarized below.

- Miguel Anjos:
    1. Introduction to semidefinite optimization (SDP)
    2. Second order cone programming
    3. Layout problems and SDP
    4. Warm-start for interior point methods in discrete optimization

- Etienne de Klerk:
    1. SDP and symmetry
    2. Matrix algebras and SDP
    3. Introduction to sum of squares and SDP
    4. The Lovasz Theta number and related topics
    5. Computer software for polynomial optimization
- Christoph Helmberg:
    1. The generic bundle method
    2. Cutting planes and spectral bundle method
    3. Spectral graph theory and SDP
    4. Eigenvalues and SDP
- Florian Jarre:
    1. Basic theory of interior point methods
    2. Interior point methods and selfconcordance
    3. The augmented primal-dual method for conic problems
    4. Optimality conditions for nonlinear SDP
- Veronica Piccialli:
    1. Low rank methods for SDP
    2. Algorithms for the SDP relaxation of Max-Cut
    3. Large-scale approaches to Max-Cut
    4. Hands-on experience with SDP software
- Franz Rendl:
    1. Conic duality
    2. Interior Point methods in practice
    3. Semidefinite and copositive relaxations in combinatorial optimization
    4. The stability number as a copositive program

3.3 Format of the Institute

The scientific program of the EURO summer institute consisted of the following parts. First, the senior scientists gave tutorial lectures, which were scheduled before lunch. The wednesday of the first week was reserved for the participants. Each participant had a twenty minutes slot to explain the project or problem she is working on. The afternoons were reserved for problem solving sessions and teamwork sessions. Moreover, we organized some hands-on sessions to introduce software for semidefinite optimization, which is available through the internet. The last day was again dedicated to the participants, who gave a progress report on what they had learned during the summer institute.

In summary, this format was well received both by the senior scientists and also by the participants.

A Lecture

Program Overview EURO Summer Institute (ESI) 2010

20.08.2010 - 03.09.2010

	9:00 - 9:50	9:50 - 10:30	10:30-11:00	11:00 - 11:50	11:50 - 12:30	12:30 - 14:00	14:00 - 15:30	15:30-16:00	16:00 - 18:00	evening
FRI, 20.08.10										welcome & get-together (18:00, room I.-2.01)
SAT, 21.08.10	meeting at 10:00 in seminar room I-2.01 for further information									BBQ at Uniwirt (18:30)
SUN, 22.08.10	boat trip at lake "Wörthersee", lunch at Restaurant Sille in Reifnitz (meeting at 9:20 at the student house)									
MON, 23.08.10	Anjos 1	Rendl 1	*break*	Rendl 2	Piccialli 1	*lunch (Uniwirt)*	teamwork	*break*	teamwork	
TUE, 24.08.10	Anjos 2	Helmberg 1	*break*	Helmberg 2	de Klerk 1	*lunch (Uniwirt)*	teamwork	*break*	teamwork	
WED, 25.08.10	participant presentation	participant presentation	*break*	participant presentation	participant presentation	*lunch (Uniwirt)*	participant presentation	*break*	participant presentation	
THU, 26.08.10	Anjos 3	de Klerk 2	*break*	Computer	Computer	*lunch (Uniwirt)*	teamwork	*break*	teamwork	
FRI, 27.08.10	Helmberg 3	Anjos 4	*break*	Computer	Computer	*lunch (Uniwirt)*	teamwork			"Altstadtzauber" (city festival with a flea market, live music, food etc.)
SAT, 28.08.10	free, soccer, tennis, beachvolleyball									
SUN, 29.08.10	bustrip through Carinthia, including a short walk in the mountains									
MON, 30.08.10	Helmberg 4	Jarre 1	*break*	Jarre 2	teamwork	*lunch (Restaurant Lakeside)*	teamwork	*break*	teamwork	
TUE, 31.08.10	Piccialli 2	Jarre 3	*break*	Jarre 4	teamwork	*lunch (Restaurant Lakeside)*	teamwork	*break*	teamwork	
WED, 01.09.10	Piccialli 3	de Klerk 3	*break*	de Klerk 4	teamwork	*lunch (Restaurant Lakeside)*	teamwork	*break*	teamwork	
THU, 02.09.10	Piccialli 4	Rendl 3	*break*	Rendl 4	teamwork	*lunch (Restaurant Lakeside)*	teamwork	*break*	teamwork	farewell dinner at Restaurant Landhaushof (19:00)
FRI, 03.09.10	participant presentation	participant presentation	*break*	participant presentation	participant presentation	*lunch (Restaurant Lakeside)*				

4 Social Programme

The social programme is an important part of the EURO summer institutes and consisted of the following activities. Throughout the institute, there were swimming facilities as well as football and beach volleyball fields available.

- Friday, Aug 20 (evening): Welcome Reception at the university
- Saturday August 21 (evening): Barbecue at Uniwirt
- Sunday August 22 (all day) Boat trip on lake Wörthersee. Stops in Velden and Reifnitz (lunch at Restaurant Sille), then return to Klagenfurt.
- Friday August 29 (evening): City festival "Altstadtzauber" featuring flea market, several stages with live music, food, variety of different artists.
- Saturday August 28 (afternoon) soccer, tennis, beach volleyball, swimming in the lake
- Sunday August 29 (all day) Bus trip through Carinthia, visiting
  – a guided tour through the city centre of Klagenfurt
  – visit of the cathedral in Maria Saal
  – visit of the historical site 'Herzogstuhl'
  – visit of the castle 'Hochosterwitz' including lunch,
  – mountain hike on 'Dobratsch' near Villach.
- Thursday September 2 (evening), Farewell dinner at Restaurant Landhaushof in the center of Klagenfurt.

In the Lecture room

5 Financial Report

5.1 Income:

EURO	14,000
ÖGOR	1,000
Universität Klagenfurt	2,500
Privatstiftung Kärntner Sparkasse	5,000
Total:	22,500

5.2 Expenses:

Secretariat	1,200.-
Organizers expenses	2,154.-
Fees infrastructure	1,680,–
Accommodation Senior Lecturers	2,003.-
Accomodation 17 participants	4,688.-
Travel Senior Lecturers	1,400.-
Meals (all participants)	7,369.-
Social Programme	2,006.-
Total	22,500.-

Klagenfurt, December 17, 2010 Franz Rendl