Multi-Objective Optimisation

Jakob Bossek

20 June 2022

1 Seminar description

Dr. Jakob Bossek
Chair for AI Methodology (Informatik 14)

The goal in optimisation is to find parameter values that maximise (or minimise) a given objective function. Examples for classical combinatorial optimisation problems are the Minimum Spanning Tree problem (MST), the Single-Source Shortest Path Problem (SSSP) or the Travelling Salesperson Problem (TSP) all of which have obvious and important applications, e.g., in logistics and vehicle routing. In practise however, we are rarely faced with problems with a single objective function. Instead, there are several objectives that require simultaneous optimisation: imagine each edge of an input instance to the aforementioned graph problems having two or more weights per edge. Than the component-wise summation of the edge-weights yields a problem with multiple objective function. In the domain of Multi-Objective Optimisation (MOO) these objectives are usually conflicting and there is no single global optimum. Instead there is a set of so-called trade-off solutions that we aim to calculate. Unfortunately, but not surprising, multi-objective problems are usually harder than their single-objective counterparts. In fact, the multi-objective MST and SSSP are NP-hard. Moreover, the solution set can be exponentially large leading to intractability problems. In this seminar we will learn about algorithmic approaches to tackle multi-objective continuous and combinatorial optimisation problems. A sample of the topics: exact approaches, scalarisation methods, heuristic algorithms with no performance guarantees, but strong success in the wild. We will also dive into tackling multi-objective problems in the field of (Automated) Machine Learning and (Automated) Artificial Intelligence.

This block seminar course will be held in English, towards the end of 2023 summer semester. Enrolment is restricted to at most 18 Bachelor or Master students, preferably with a background in (heuristic) optimisation. Students will work in groups of at most two on different MOO-related topics.. Each group will be assigned a paper from the research literature, which will serve as the starting point for an in-depth investigation of a specific topic. The results of this investigation will be presented in class and compiled into a report.

2 Seminar procedure

In an introductory *kick-off meeting* we will present our ideas on the seminar procedure. Students will be divided into groups of two[1] by us using a semi-random process aimed at ensuring diversity and complementarity of experience within the groups. Each group will be assigned a publication from the field of multi-objective optimisation, which serves as a entry point into the respective topic. The groups dive into the topic by performing literature search and compile a survey-like report giving an overview of the respective field while focusing on a couple of focus-papers in more detail. The results are presented in an oral presentation.

- The seminar will take place as a block-seminar in August or September 2023.

- 30 minutes talk (each student must contribute equally) plus additional 30 minutes of in-depth discussion.

- Seminar report: 20 pages max, using the LaTeX template provided by us, including references, figures etc. A statement outlining the contributions of each team member is mandatory and will be used as one basis for assessment.

3 Oral Presentation

- Use the provided LaTeX-template (see website) for the presentation slides (we do not allow Power-Point presentations).

- Do not lose yourself in unimportant details too much.

- Keep the time limit (30min; a little less is OK, a little more is *not* OK).

- Each group member should participate equally.

4 Report

- Note that the paper assigned to your group is *not necessarily the most relevant*. We expect you to take it as a 'first clue', deep-dive into the literature and compile the most relevant aspects. Discovering and deciding which papers are important is part of your work. Note also that not everything has to be covered in full detail. It is up to the group to decide which papers and content is most relevant.

- Use the provided LaTeX-template (see website) for the final report and submit in PDF-format (we do not accept MS-Word reports).

---

[1] If the number of participants is odd, there will be a single one person group. The assigned topic will be of reduced workload though.

- Stick to the page limit: 20 pages using the prescribed format, including references, figures etc.

- A report contains introduction, conclusion and bibliography among other sections.

5 Criteria for successful completion

- Preparation of a seminar report in LaTeX (max. 20 pages, using the prescribed format, PDF)

- 30 minute presentation + 30 minutes discussion

- Meeting all deadlines

- Attendance of all mandatory meetings

- **Grading**: 60% report, 30% presentation incl. answers to questions and 10% participation in discussions on other presentations.

6 Important Dates

- Kickoff meeting: tba

- Progress update (via e-mail, bullet points are OK, but do give us some details): **9 June 2023, 18:00 CEST** (hard deadline!)

- Final report due (PDF via e-mail): **30 July 2022, 18:00 CEST** (hard deadline!)

- Block seminar: August or September 2023 (exact date tba)