

REPORT ON A SHORT-TERM SCIENTIFIC MISSION (STSM) TO BME, BUDAPEST

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ABSTRACT. This document contains a report on a short term scientific mission (STSM) of the author of his visit to the Budapest University of Technology and Economics (BME), and forms part of the author's application to obtain STSM funding from the COST TD1207 action "Mathematical Optimization in the Decision Support Systems for Efficient and Robust Energy Networks". The STSM was carried out in the period May 19–26, 2015.

1. PURPOSE OF THE STSM

Polynomial optimization problems appear frequently in energy optimization applications. Two important examples are:

- (1) The optimal power flow problem; see e.g. [4] and the references therein.
- (2) The pooling problem that arises in oil refinery; see e.g. the review by Haugland [5].

From the mathematical optimization perspective, these problems may be categorized as nonlinear network flow problems, where the nonlinearity is polynomial (often bilinear), or may be modeled as such.

Although these problems are well-studied, recent developments in convex approaches to polynomial optimization problems (POPs) offer some new perspectives. In particular, there has been a great deal of research in the last 15 years or so into semidefinite (or conic) programming approximations for POPs, following the seminal work by Lasserre [6]. The pooling problem involves only quadratic (bilinear) polynomials, and for this case there has been specialized research, e.g. [7] and [2].

To be clear, the state-of-the-art in software for the pooling problem has produced impressive results, as seen for example in the APOGEE software [8]. The approach used in APOGEE involves linearization and mixed integer programming sub-problems, and is therefore quite different from the planned investigation.

Nevertheless, even though it is not realistic to expect that one will be able to improve on the state-of-the-art computation through semidefinite programming (SDP) approaches any time soon, the recent developments warrant a thorough investigation of the perspectives. Indeed, preliminary work on SDP hierarchies has shown some promise, especially for the optimal power flow problem [4].

The purpose of the STSM was to start an investigation on the merits of the semidefinite programming approaches.

Date: May 26, 2015.

2. DESCRIPTION OF THE WORK CARRIED OUT DURING THE STSM

The STSM involved a one-week visit of the author to BME, hosted by professors Tibor Illés and Marianna Eisenberg-Nagy. There was an elaborate exchange of ideas on the following topics:

- (1) Numerical solution techniques for the pooling problem, and generalized pooling problem;
- (2) Optimization models and solution techniques for energy auctions.

Concerning the first topic, the BME researchers explained the work they had done in the past on the pooling problem. By lucky coincidence, Dr. Zsolt Csizmadia was also visiting BME at the same time. (He is a former PhD student of Dr. Illés and active in the development of the optimization software XPRESS-MP.) He shared his experiences on solving pooling problems using successive linear programming techniques.

We also studied recent literature on the pooling problem, including the recent papers [1, 3]. Finally, we started testing various SDP approaches on test problems from the test library maintained by Alfaki at <http://www.ii.uib.no/~mohammeda/spooling/>

Concerning the second item (energy auctions), the BME group gave a presentation of their recent work on the topic (presented by the PhD student Richard Molnár-Szipai), followed by discussions.

3. DESCRIPTION OF THE MAIN RESULTS OBTAINED

The following results were obtained:

- (1) A literature study was performed on solution techniques and test problems for the pooling problem, as detailed above. Some instances that cause difficulty for state-of-the-art solvers were identified.
- (2) A preliminary Matlab implementation was done of novel SDP relaxation techniques for small pooling problem instances.

Due to the short time frame, no detailed computational results were obtained, but preliminary findings were promising.

4. FUTURE COLLABORATION WITH THE HOST INSTITUTION

The author aims to continue his long-standing collaboration with the host institution. In particular, detailed plans are being discussed to meet again to further work out some ideas discussed during this STSM.



Signature.

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