# Final Report
# Short Term Scientific Mission to Germany
# July 31 – August 9, 2018

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## 1 Purpose of the stsm

The main goal of this stsm is to get access to data and new applied techniques as the specially designed equipment exist in The Heidelberg Collaboratory for Image Processing (HCI) of The University of Heidelberg and The Fraunhofer Institute for Industrial Mathematics (ITWM).

This scientific visit will enable to continue the exiting collaboration towards joint publications, grant proposals and help in the organization and participation in the ESGI planned to beheld in Innsbruck during March 2019.

All of these will contribute deeply to my personal career and academic developments.

## 2 Description of work carried out during the stsm

### 2.1 In HCI

During my stay in Heidelberg we have been focusing on the problem of reconstructing a vectorized binary image $u \in \{0,1\}^n$ from a limited number of tomographic projections. This problem can be formulated as a system of linear equations with binary variables. Our achievement is the new model of the problem as a non-convex feasibility problem. Then we propose an alternating projection method taken from **convex** feasibility problems. The goal is extend Hesse et al. [2] method to include bounded perturbations resilient and then introduce their superiorized version for example with total variation. So far we proved the bounded perturbations resilient and we plan to implement the algorithms so we can test it on the above image reconstruction problem. When this is completed we wish to gather the results towards joint publication and simultaneously apply for a Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) or German-Israeli Foundation for Scientific Research and Developments (GIF) grant in the upcoming year.

another direction which was studied during my stay is the commonly used condition which plays an important role in many real-world problems. We started and keep on searching/defining an academical scenario where the involved matrix $M$ satisfies the key condition eq. (32) of [2, Thm. III.15]: $M$ has full rank and

$$(1-\delta_{2s})\|x\|_2^2 \leq \|M^{\dagger}Mx\|_2^2, \qquad \forall x \in A_{2s}. \tag{1}$$

## 2.2 In ITWM

During my stay in ITWM I have officially nominated as Ms. Esther Bonacker PhD degree co-advisor together with Prof. Dr. Karl-Heinz Küfer (Division Director Optimization and Head of Department Optimization - Operations Research, ITWM). Jointly with her and Karl-Heinz, we have studied the following topics.

1. Proved the bounded perturbation resilience of the heavy ball and the surrogate constraint methods. This enabled, during my stay, to introduced the superiorized version of the methods and implement them for Intensity-modulated radiation therapy (IMRT) treatment planning problems. Within The Fraunhofer ITWM we have implemented the methods on the unique software and witness some primary results emphasizing the advantages of our propose methods. Still comparison with other methods is needed and this is our ongoing project. Since in the last couple of months the gemstone problem attracts less attention, the main application was IMRT. In the next months we'll prove the convergence rate of the perturbed methods and compare them with some existing methods. Ms. Esther Bonacker will visit me during November and February regarding these topics. A joint publication is currently composed focus on the results achieved in above.

2. A company related to The Fraunhofer ITWM will join the ESGI will present a problem in the ESGI held in Innsbruck in the March 2019. During the next month we will have several conference calls to define the exact problem.

## References

[1] A. Gibali, K.-H. Küfer, D. Reem and P. Süss, A generalized projection-based scheme for solving convex constrained optimization problems, accepted for publication in *Computational Optimization and Applications*, 2018. DOI:10.1007/s10589-018-9991-4

[2] R. Hesse, D. R. Luke and P. Neumann, Alternating Projections and Douglas-Rachford for sparse affine feasibility, *IEEE Transactions on Signal Processing* **62** (2014), 4868–4881.