Project code: **PN-III-P4-ID-PCE-2016-0190**
Contract: **96/12.07.2017**
Project title: *Equilibrium and optimization problems: theoretical and computational approaches*
Project acronym: EQOPTIM
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SCIENTIFIC RESEARCH REPORT No. 2/2018

I. Research Team

Prof. Gábor KASSAY (project leader), Ph.D.
Prof. Nicolae POPOVICI, Ph.D. habil.
Assoc. Prof. Cornel Sebastian PINTEA, Ph.D.
Assoc. Prof. Szilárd Csaba LÁSZLÓ, Ph.D. habil.
Lect. Prof. Zsolt DARVAY, Ph.D.
Lect. Prof. Anca GRAD, Ph.D.
Asist. Prof. Livia Mihaela BERCHEŞAN (maiden name MIHOLCA), Ph.D.
Corina Ioana BLIDAR, Ph.D. Student
Petra-Renáta RIGÓ (maiden name TAKÁCS) , Ph.D. Student

II.Project summary and objectives

(a) The project is mainly motivated by the growing interest in the literature regarding sensitivity, openness/metric regularity, variational principles, and practical applications concerning equilibrium and optimization problems, interest which clearly shows that these fields are appropriate for applying the modern tools of nonlinear analysis. The aim of the seven objectives of the project is to bring to light new concepts and approaches within the following specific objectives:

Obj. 1 *Parametric equilibrium problems*
Obj. 2 *Variational principles for vector equilibrium problems*
Obj. 3 *Vector optimization problems in connection with differential inclusions*
Obj. 4 *Duality and optimality conditions for set-valued optimization*
Obj. 5 *Numerical methods for equilibrium problems*
Obj. 6 *Interior-point methods for scalar optimization problems*
Obj. 7 *Algorithms for image processing and optimal location*

(b) All objectives planned for 2018 have been achieved as indicated in Section III below.

III. Scientific results

(a) Publications (books and articles)

1 book and **12 papers have been completed in 2018**:

- **1 book** published by a **prestigious publishing house** (B1 in the next table);
- **8 articles** have been **published** in **WOS – indexed journals** (A1 – A8 in the next table);
- **1 article** has been **accepted** for publication in a **WOS – Emerging Sources Citation indexed journal -** (A9 in the next table);
- **3 papers have been submitted to ISI journals** (A10 – A12 in the next table).

Ref.	Article	Obiectives
C1	**Gábor Kassay**, Vicențiu Rădulescu: *Equilibrium Problems and Applications*, **Academic Press**, ISBN: 978-0-12-811029-4, 440 pages	Obj. 1 Obj. 2 Obj. 5
A1	**Zsolt Darvay**, **Petra-Renáta Takács**: *Large-step interior-point algorithm for linear optimization based on a new wide neighbourhood*, **Central European Journal of Operations Research,** 26 (2018) (3), 551-563, DOI: 10.1007/s10100-018-0524-0 [JCR Science Edition 2017 IF: 0,73]	Obj. 6
A2	**Petra-Renáta Rigó**, **Zsolt Darvay**: *Infeasible interior-point method for symmetric optimization using a positive-asymptotic barrier*, **Computational Optimization and Applications,** 71 (2018) (2), 483-508, DOI: 10.1007/s10589-018-0012-4 [JCR Science Edition 2017 IF: 1,413]	Obj. 6
A3	Adela Capătă, **Gábor Kassay**, Suliman Al-Homidan: *Existence results for strong vector equilibrium problems with applications*, **Journal of Nonlinear and Convex Analysis**, 19 (2018) (7), 1163-1179 [JCR Science Edition 2017 IF: 0,56]	Obj. 1 Obj. 3
A4	**Zsolt Darvay**, **Petra Renáta Rigó**: *New interior-point algorithm for symmetric optimization based on a positive-asymptotic barrier function*, **Numerical Functional Analysis and Optimization**, First Online 10 October 2018, DOI: 10.1080/01630563.2018.1492938 [JCR Science Edition 2017 IF: 0,827]	Obj. 6
A5	Ovidiu Bagdasar, Stuart Berry, Sam O'Neill, **Nicolae Popovici**, Ramachandran Raja: *Traffic assignment: Methods and simulations for an alternative formulation of the fixed demand problem*, **Mathematics and Computers in Simulation**, 155 (2019), 360–373, DOI: 10.1016/ j.matcom.2018.08.004 [JCR Science Edition 2017 IF: 1,476]	Obj. 7
A6	Soodabeh Asadi, Hossein Mansouri, **Zsolt Darvay**, Goran Lesaja, Maryam Zangiabadi: *A long-step feasible predictor-corrector interior-point algorithm for symmetric cone optimization*, **Optimization Methods and Software**, First Online 30 October 2018, DOI: 10.1080/ 10556788.2018.1528248 [JCR Science Edition 2017 IF:1,183]	Obj. 6

A7	Soodabeh Asadi, Hossein Mansouri, **Zsolt Darvay**, Maryam Zangiabadi, Nezam Mahdavi-Amiri: *Large-Neighborhood infeasible predictor-corrector algorithm for horizontal linear complementarity problems over Cartesian product of symmetric cones*, **Journal of Optimization Theory and Applications**, First Online 16 October 2018, DOI: 10.1007/ s10957-018-1402-6 [JCR Science Edition 2017 IF:1,234]	Obj. 6
A8	Luminita Barbu, Gheorghe Morosanu, **Cornel Pintea**: *A nonlinear elliptic eigenvalue–transmission problem with Neumann boundary condition*, **Annali di Matematica Pura ed Applicata**, First Online: 29 October 2018, DOI: 10.1007/s10231-018-0801-5 [JCR Science Edition 2017 IF: 1,066]	Obj. 2
A9	**Livia Mihaela Berchesan (Miholca)**: *A generalized Ekeland's variational principle for vector equilibria*, **Studia Universitatis Babes-Bolyai Mathematica**, accepted	Obj. 2
A10	**Szilárd Csaba László**: *Convergence rates for an inertial algorithm of gradient type associated to a smooth nonconvex minimization*, **Mathematical Programming**, under review	Obj. 2 Obj. 4
A11	Suliman Al-Homidan, Qamrul Hasan Ansari, **Gábor Kassay***: Vectorial form of Ekeland's Variational Principle with applications to vector equilibrium problems*, **Optimization**, under review	Obj. 2
A12	Suliman Al-Homidan, Qamrul Hasan Ansari, **Gábor Kassay***: Takahashi's minimization theorem and some related results in quasi-metric spaces*, **Journal of Fixed Point Theory and Applications**, under review	Obj. 2

The main results obtained in these twelve papers are described below.

C1. The project leader has published in collaboration with Vicențiu D. Rădulescu (AGH University of Science and Technology, Krakow, Poland and IMAR, Bucharest) the book entitled *Equilibrium Problems and Applications,* edited by Academic Press (Elsevier), 2018. It has 440 pages and its ISBN is 978-0-12-811029-4.

This monograph is a systematic exposition of the authors' research on general equilibrium models arising in optimization, economics, and applied sciences. It is intended to serve both as a graduate text on aspects of general equilibrium theory and as an introduction, for economists and mathematicians working in mathematical economics, to current research in a frontier area of general equilibrium theory.

This book presents a systematic approach to problems in economic equilibrium based on fixed-point arguments and rigorous variational analysis methods. It describes the highest-level research on the classical theme, fixed points and economic equilibria, in the theory of mathematical economics, and also presents basic results in this area, especially in the general equilibrium theory and non-cooperative game theory.

This volume can serve as a graduate-level textbook on mathematical economics as well as an advanced monograph for students and researchers who are concerned about rigorous mathematical treatment in the social sciences.

A1. In the paper [Large-step interior-point algorithm for linear optimization based on a new wide neighbourhood, Central European Journal of Operations Research, 26 (2018) (3), 551-563, DOI: 10.1007/s10100-018-0524-0] Zsolt Darvay together with Petra-Renáta Takács (Rigó) introduced a new wide neighbourhood of the central path and a large-step interior-point algorithm for linear optimization. Usually, the large-step algorithms are more efficient in practice, while the theoretical complexity of the short-step ones is generally better. In spite of this fact, the authors proved that the proposed interior-point algorithm has the same complexity as the best short-step algorithms.

A2. In the article [Infeasible interior-point method for symmetric optimization using a positive-asymptotic barrier, Computational Optimization and Applications, 71 (2018) (2), 483-508, DOI: 10.1007/s10589-018-0012-4] Petra-Renáta Rigó and Zsolt Darvay generalized the algorithm presented in the paper [New interior-point algorithm for symmetric optimization based on a positive-asymptotic kernel function, Numerical Functional Analysis and Applications, DOI: 10.1080/01630563.2018.1492938] for the case when no feasible solution is available. The authors showed that the associated barrier can not be derived from a usual kernel function, hence they used the introduced notion of positive-asymptotic kernel function. The novelty of this algorithm is that it uses one feasibility step and only one centering step in each iteration. Moreover, the authors gave promising numerical results in case of linear programming, semidefinite optimization and second-order cone programming problems, that are special cases of symmetric optimization.

A3. In the paper [*Existence results for strong vector equilibrium with applications,* Journal of Nonlinear and Convex Analysis, 19 (2018), 1163-1179], **Gábor Kassay (the project leader)** has studied jointly with Adela Capătă (Technical University of Cluj-Napoca) and Suliman Al-Homidan (King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia) the equilibrium problem in the special case when the generating bifunction can be represented by the sum of two bifunctions taking values in an ordered topological vector space. The authors gave sufficient conditions for the existence of a strong solution. It has to be mentioned that there are few results in the literature dealing with the strong equilibrium problem, and, in general, some rather restrictive hypotheses are imposed. By introducing a new type of monotonicity, the authors succeeded to obtain their results under usual continuity assumptions.

As applications, sufficient condition for the existence of solutions of vector optimization problems with constraints have been obtained.

A4. In the paper [*New interior-point algorithm for symmetric optimization based on a positive-asymptotic barrier function*, Numerical Functional Analysis and Optimization, First Online 10 October 2018, DOI: 10.1080/01630563.2018.1492938] **Zsolt Darvay** and **Petra-Renáta Rigó** proposed a new interior-point algorithm for symmetric optimization problems, which is based on a new search direction. The authors applied the algebraically equivalent transformation technique in order to obtain the new search directions. They introduced a new notion, the concept of the positive-asymptotic kernel function. Furthermore, they proved that the algorithm solves the problem in polynomial time and has the same complexity as the best known interior-point algorithms for symmetric optimization.

A5. In the paper [*Traffic assignment: Methods and simulations for an alternative formulation of the fixed demand problem*, Mathematics and Computers in Simulation, 155 (2019), 360–373, DOI: 10.1016/j.matcom.2018.08.004] **Nicolae Popovici,** jointly with Ovidiu Bagdasar, Stuart Berry,

Sam O'Neill (University of Derby, UK) și Ramachandran Raja (Ramanujan Centre for Higher Mathematics, Alagappa University, Karaikudi, India), examined discrete and continuous optimisation and equilibrium-type problems for a simplified parallel link traffic model, using a variance based approach. Various methodologies used for solving these problems (brute force, dynamic programming, tabu search, steepest descent) are explored and comparison is made with the Beckmann cost function employed in transport modelling.

A6. In the paper [*A long-step feasible predictor-corrector interior-point algorithm for symmetric cone optimization*, Optimization Methods and Software, First Online 30 October 2018, DOI:10.1080/10556788.2018.1528248] **Zsolt Darvay,** together with Soodabeh Asadi, Hossein Mansouri, Maryam Zangiabadi (Department of Applied Mathematics, Faculty of Mathematical Sciences, Shahrekord University, Shahrekord, Iran) and Goran Lesaja (Department of Mathematical Sciences, Georgia Southern University, Statesboro, GA, USA), presented a predictor-corrector interior-point algorithm for symmetric cone optimization, which works in a large neighborhood of the central path. The algorithm starts with a feasible point and its iteration bound is identical with the best known short-step methods. In this way they closed the complexity gap between long- and short-step methods for these kinds of problems. Preliminary numerical results show that this method is more efficient than the version of the algorithm that is not based on the predictor-corrector scheme.

A7. In the article [*Large-Neighborhood infeasible predictor-corrector algorithm for horizontal linear complementarity problems over Cartesian product of symmetric cones*, Journal of Optimization Theory and Applications, First Online 16 October 2018, DOI: 10.1007/s10957-018-1402-6] **Zsolt Darvay** and his co-authors, Soodabeh Asadi, Hossein Mansouri, Maryam Zangiabadi (Department of Applied Mathematics, Faculty of Mathematical Sciences, Shahrekord University, Shahrekord, Iran) and Nezam Mahdavi-Amiri (Faculty of Mathematical Sciences, Sharif University of Technology, Tehran, Iran), presented the first large-neighborhood interior-point algorithm for the horizontal linear complementarity problems over Cartesian product of symmetric cones. They analyzed a predictor-corrector infeasible interior-point algorithm for this general class of problems, and proved polynomial complexity for the class of commutative search directions. They discussed also some particular search directions and considered the case of feasible starting points as well.

A8. In the paper [*A nonlinear elliptic eigenvalue–transmission problem with Neumann boundary condition*, Annali di Matematica Pura ed Applicata, First Online: 29 October 2018, DOI: 10.1007/s10231-018-0801-5], **Cornel Pintea** jointly with Luminița Barbu (Faculty of Mathematics and Computer Science, Ovidius Universiy, Constanța) and Gheorghe Moroșanu (Romanian Scientists Academy, Bucharest, and, Babeș-Bolyai University, Cluj-Napoca), have proved the the existence of a sequence of eigenvalues for the eigenvalue-transmission problem associated with the p-Laplacian acting in Ω_1 and the q-Laplacian acting in Ω_2, $1<p<q$, with Dirichlet-Neumann conditions on the interface separating the two sub-domains Ω_1 and Ω_2 of some bounded domain Ω of $\mathbb{R}^N$, $N\geq 2$. The proof is based on the Ljusternik-Schnirelman principle. Using the method of Lagrange multipliers for constrained minimization problems, we show the existence of an eigenfunction in every level se of some integral functional, whenever $2\leq p<q$. The case of Robin conditions on $\partial\Omega$ and the Riemannian setting are also addressed.

A9. Ekeland's variational principle is known to have many applications in nonlinear analysis and optimization. Several authors have extended the Ekeland's variational principle for vector-valued bifunctions taking values in an ordered vector space. Araya, Kimura and Tanaka established in the paper [*Existence of vector equilibria via Ekeland's variational principle*, Taiwanese J. Math. 12 (2008) (8), 1991-2000] a version of Ekeland's variational principle for vector-valued bifunctions, which is expressed by the existence of a strict approximate minimizer for a weak vector equilibrium problem. Their approach is based on the assumption that the equilibrium bifunction *f* satisfies the vector triangle property. In the paper [*A generalized Ekeland's variational principle for vector equilibria*, acceptată pentru publicare la revista Studia Universitatis Babes-Bolyai Mathematica, indexată WOS - Emerging Sources Citation Index], **Livia-Mihaela Berchesan (Miholca)** gives an improvement of Theorem 2.1 in Araya et. al. The author widen the class of the vector bifunctions for which the Ekeland's variational principle is applicable.

A10. In the work [*Convergence rates for an inertial algorithm of gradient type associated to a smooth nonconvex minimization*, under review] **Szilárd Csaba László** investigates an inertial algorithm of gradient type in connection with the minimization of a nonconvex differentiable function. The algorithm is formulated in the spirit of Nesterov's accelerated convex gradient method, and due to our best knowledge, is the first successful attempt to extend Nesterov's algorithm to the nonconvex case. We show that the generated sequences converge to a critical point of the objective function, if a regularization of the objective function satisfies the Kurdyka-Lojasiewicz property. Further, we provide convergence rates for the generated sequences and the function values formulated in terms of the Lojasiewicz exponent. We obtain polynomial and p-th order convergence rates, for any positive p, and we show that this result is optimal in the sense that exponential convergence rates cannot be obtained. We also emphasize a possible extension of our algorithm to a modified nonconvex FISTA algorithm in the spirit of the work of A. Chambolle and Ch. Dossal [*On the convergence of the iterates of the fast iterative shrinkage/thresholding algorithm*, J. Optim. Theory Appl. 166 (2015) (3), 968-982], where the objective function is the sum of a nonsmooth convex and a nonconvex smooth function.

A11. In the paper [*Vectorial form of Ekeland's Variational Principle with applications to vector equilibrium problems*, under review], the **project leader, Gabor Kassay**, together with Suliman Al-Homidan (King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia) and Qamrul Hasan Ansari (Aligarh Muslim University, Aligarh, India) derived an Ekeland type variational principle for the equilibrium and quasi-equilibrium problems. The bifunctions involved take values in a vector space without any topological structure. The demanding triangular inequality for bifunctions (which is assumed in most of the results within the literature and appears rather restrictive: the particular case of variational inequalities are not covered under such hypothesis) is avoided in their results. Then by using their variational principle, the authors obtained some existence results for solutions of vector equilibrium problems and vector quasi-equilibrium problems without any convexity assumptions.

A12. The **project leader** established in the paper [*Takahashi's Minimization Theorem and Some Related Results in Quasi-metric Spaces,* under review], written in collaboration with Suliman Al-Homidan (King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia) and Qamrul

Hasan Ansari (Aligarh Muslim University, Aligarh, India), the Takahashi's minimization theorem in the setting of quasi-metric spaces and provided its equivalence with Ekeland's variational principle. The authors presented also an equilibrium version of Ekeland's variational principle and deduced an equivalent chain of theorems containing Takahashi's minimization theorem, Ekeland's variational principle, the equilibrium version of Ekeland's variational principle and Caristi-Kirk's fixed point theorem for set-valued maps in the setting of quasi-metric spaces. As applications, they gave an error bound for the solution set of the equilibrium problems and provide sufficient conditions for the existence of weak sharp solutions of equilibrium problems.

IV. Dissemination of research results

The scientific results mentioned within Section III of this report have been presented by the authors (members of the project research team) at **27** conferences, workshops and research seminars in Romania or abroad, namely:

- **9 conferences and workshops abroad [**CS1, CS4, CS15-CS18, CS20, CS21 and CS24 in the next table, among which **1 invited talk];**
- **1 research seminars abroad [**CS19 in the next table**];**
- **6 conferences in Romania [**CS8-CS11, CS13 and CS14 in the next table, among which **1 invited talk]];**
- **11 research seminars in Romania [**CS2, CS3, CS5-CS7, CS12, CS22, CS23 and CS25-CS27 in the next table**].**

Ref.	**Conference/workshop /research seminar**
CS1	**Gábor Kassay** (**invited plenary speaker**): *Equilibrium problems: are they of fixed point or Hahn-Banach type?*, The 7th International Workshop on Fixed Point Theory & Applications, Dhahran, Saudi Arabia, January 03-04, 2018
CS2	**Szilárd Csaba László**: *A second order dynamical system with variable damping associated to a nonconvex minimization*, Seminar of the Research Group on Analysis and Optimization, Babeş-Bolyai University, Cluj-Napoca, Romania, March 1, 2018, http://www.cs.ubbcluj.ro/~grupanopt/
CS3	**Cornel Pintea**: *Characterizations of some properties of the closed convex sets through their Gauss range*, Seminar of the Research Group on Analysis and Optimization, Babeş-Bolyai University, Cluj-Napoca, Romania, March 8, 2018, http://www.cs.ubbcluj.ro/~grupanopt/

CS4	**Szilárd Csaba László**: *Approaching nonsmooth nonconvex minimization through second order proximal-gradient dynamical systems*, Games, Dynamics & Optimization (GDO2018), Vienna, Austria, March 13–15, 2018, https://mathematik.univie.ac.at/fileadmin/user_upload/f_mathematik/Vortraege/2017_18/Poster-6.pdf
CS5	**Petra Renáta Rigó**: *Interior-point methods for linear complementarity problems*, Seminar of the Research Group on Analysis and Optimization, Babeş-Bolyai University, Cluj-Napoca, Romania, March 15, 2018, http://www.cs.ubbcluj.ro/~grupanopt/
CS6	**Anca Grad**: *A penalty scheme with a backward step and inertial effects*, Seminar of the Research Group on Analysis and Optimization, Babeş-Bolyai University, Cluj-Napoca, Romania, March 22, 2018, http://www.cs.ubbcluj.ro/~grupanopt/
CS7	**Nicolae Popovici**: *A systematization of convexity and quasiconvexity concepts for set-valued maps, defined by l-type and u-type preorder relations*, Seminar of the Research Group on Analysis and Optimization, Babeş-Bolyai University, Cluj-Napoca, Romania, March 29, 2018, http://www.cs.ubbcluj.ro/~grupanopt/
CS8	**Gábor Kassay** (**member of the Scientific Committee**): *On a sufficient condition for weak sharp efficiency in multiobjective optimization*, First Romanian Itinerant Seminar on Mathematical Analysis and its Applications (RISMAA), Cluj-Napoca, Romania, April 20-21, 2018, http://www.cs.ubbcluj.ro/1st-rismaa/
CS9	**Nicolae Popovici** (**member of the Scientific Committee**): *A systematization of quasiconvexity concepts for set-valued maps*, First Romanian Itinerant Seminar on Mathematical Analysis and its Applications (RISMAA), Cluj-Napoca, Romania, April 20-21, 2018, http://www.cs.ubbcluj.ro/1st-rismaa/
CS10	**Cornel Pintea:** *Characterizations of some properties of the closed convex sets through their Gauss range*, First Romanian Itinerant Seminar on Mathematical Analysis and its Applications (RISMAA), Cluj-Napoca, Romania, April 20-21, 2018, http://www.cs.ubbcluj.ro/1st-rismaa/
CS11	**Anca Grad**: *A backward step with inertial effects algorithm solving a monotone inclusion problem*, First Romanian Itinerant Seminar on Mathematical Analysis and its Applications (RISMAA), Cluj-Napoca, Romania, April 20-21, 2018, http://www.cs.ubbcluj.ro/1st-rismaa/
CS12	**Zsolt Darvay***: Classes of search directions in interior-point algorithms for linear complementarity problems*, Seminar of the Research Group on Analysis and Optimization, Babeş-Bolyai University, Cluj-Napoca, Romania, May 31, 2018, http://www.cs.ubbcluj.ro/~grupanopt/

CS13	**Gábor Kassay (invited plenary speaker):** *The equilibrium problem: a unified approach to optimization, minimax problems (game theory), variational inequalities and other interesting problems*, 12th Joint Conference on Mathematics and Computer Science, Săcuieu, Romania, June 14 – 17, 2018, http://www.cs.ubbcluj.ro/~macs/2018/
CS14	**Anca Grad:** *A monotone inclusion problem solved through an inertial algorithm with two backward steps*, 12th Joint Conference on Mathematics and Computer Science, Săcuieu, Romania, June 14 – 17, 2018, http://www.cs.ubbcluj.ro/~macs/2018/
CS15	**Nicolae Popovici:** *A general local-global extremality principle in vector optimization*, International Conference on Variational Analysis and Nonsmooth Optimization (ICVANO2018) - dedicated to Boris Mordukhovich, Halle (Saale), Germany, June 28 - July 1, 2018, https://blogs.urz.uni-halle.de/icvano/
CS16	**Gábor Kassay**: *On a sufficient condition for weak sharp efficiency in multiobjective optimization*, 2018 International Conference on Management and Operations Research, Beijing Friendship Hotel, Beijing, China, July 7-9, 2018, http://icmor.ustb.edu.cn/
CS17	**Livia Mihaela Bercheşan**: *Cyclically antimonotone vector equilibrium problems*, 29th European Conferefnce on Operational Research (EURO2018), Valencia, Spain, July 8-11, 2018, http://euro2018valencia.com
CS18	**Petra Renáta Rigó**, **Zsolt Darvay**, Tibor Illés: *Predictor-corrector interior-point algorithms for sufficient linear complementarity problems*, 16th EUROPT Workshop on Advances in Continuous Optimization, Almería, Spain, July 12-13, 2018, http://www2.ual.es/EurOPT18/
CS19	**Gábor Kassay**: *The equilibrium problem: a unified approach to optimization,minimax problems (game theory), variational inequalities and other interesting problems*, Research Seminar on Optimization, Budapest University of Technology and Economics, September 20, 2018
CS20	**Zsolt Darvay**: *Adaptive predictor-corrector interior-point algorithm based on a transformation of the central path*, The 17th International Conference on Operational Research (KOI 2018), Zadar, Croatia, September 26-28, http://hdoi.hr/koi2018/
CS21	**Petra Renáta Rigó**, **Zsolt Darvay**, Tibor Illés: *New algebraic equivalent transformation for a predictor-corrector interior-point algorithm*, The 17th International Conference on Operational Research KOI 2018, Zadar, Croatia, September 26-28, http://hdoi.hr/koi2018/
CS22	**Szilárd Csaba László**: *Convergence rates for an inertial algorithm of gradient type associated to a smooth nonconvex minimization*, Seminar of the Research Group on Analysis and Optimization, Babeş-Bolyai University, Cluj-Napoca, Romania, October 11, 2018, http://www.cs.ubbcluj.ro/~grupanopt/

CS23	**Petra Renáta Rigó**: *Predictor-corrector interior-point algorithms,* Seminar of the Research Group on Analysis and Optimization, Babeş-Bolyai University, Cluj-Napoca, Romania, October 18, 2018, http://www.cs.ubbcluj.ro/~grupanopt/
CS24	**Nicolae Popovici**: *A systematization of quasiconvexity concepts for set-valued maps,* Colloquium Vector- and Set-Valued Optimization, Wittenberg, Germany, October 25-26, 2018, https://leucorea.de/veranstaltungen/vektoren-und-mengenwertige-optimierung-2/
CS25	**Cornel Pintea**: *Strongly Minkowski sets revisited*, Seminar of the Research Group on Analysis and Optimization, Babeş-Bolyai University, Cluj-Napoca, Romania, October 25, 2018, http://www.cs.ubbcluj.ro/~grupanopt/
CS26	**Nicolae Popovici**: *Generalized convexity of vector functions w.r.t. polyhedral cones*, Seminar of the Research Group on Analysis and Optimization, Babeş-Bolyai University, Cluj-Napoca, Romania, November 8, 2018, http://www.cs.ubbcluj.ro/~grupanopt/
CS27	**Cornel Pintea**: *A nonlinear eigenvalue-transmission problem with Neumann boundary condition*, Seminar of the Research Group on Analysis and Optimization, Babeş-Bolyai University, Cluj-Napoca, Romania, November 22, 2018, http://www.cs.ubbcluj.ro/~grupanopt/

Project leader,
Prof. Gábor Kassay, Ph.D.