Research Center for Applied Mathematics in Engineering Sciences

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Areas of expertise

Numerical Analysis:
- **New methods and tools in Approximation Theory:** obtaining high accurracy representations for the reminder in approximation formulas; study of the topology of the set of unbounded divergence for approximation procedures.
- **Application of *MATHEMATICA*'s aproximation subroutines:** implementing the computation of the nonlinear functions on low cost microcontrollers.
- **High degree quadrature formulas:** improving the current accuracy of quadrature formulas by using Laurent orthogonal polynomials.
- **New algorithms for energy-minimizing curves and surfaces:** obtaining the approximation error, convergence rate, consistency and stability conditions.

Functional, Differential and Integral Equations:
- **Functional Equations**: Existence and representation of single-valued and multivalued solutions. Hyers-Ulam stability of equations in algebraic and topological structures. Applications to the stability and perturbations of Dynamical Systems.
- **Differential and Integral Equations:** Existence and uniqueness of solutions for Ordinary, Partial Differential and Integral Equations using techniques of Fixed Point Theory. Hyers-Ulam stability of Ordinary, Partial Differential Equations and Integral Equations. Hyers-Ulam stability of differential and integral operators. Monotone iterative techniques: obtaining two-sided approximations for fixed points and coupled fixed points of monotone and mixed monotone operators in ordered metric spaces.

Programming:
- **MATLAB and MATHEMATICA:** implementation and analysis of the mathematical solutions to engineering problems.

Calculus of Variations:
- **Generalized equations of Euler-Lagrange and Euler-Gauss type** used in the theory of 2D and 3D deformable models, for obtaining energy-minimizing snakes.

Geometry:
- **Geometry of image formation** in stereo vision, different camera models, calibration, system of multiple lenses and mirrors of specific type, etc.
- **Manifold learning and pattern recognition.**

Operator theory and Special functions:
- **Operator theory:** Multivalued operator theory which is about the investigation of the fixed point properties of special multivalued operators. The study of the properties of integral operators acting on various spaces of analytic functions.
- **Special functions:** Investigating the properties of special functions, Riemann zeta, Hurwitz zeta and Polylogarithm functions. Closed form evaluation and asymptotic expansion of the constants that are connected to the special functions which appear in number theory, cryptography, real analysis, etc.

Modelling:
- **Ultrasound echocardiography**: combined methods involving deformable models and active shape models.
- **Computer-aided surgery (Prosthetic medicine**): Combined methods, involving deformable surfaces and statistical modelling.

- **Dynamic image based modelling**: Myocardial wall motion tracking on image sequences, based on the methods of dynamic programming.
- **Pattern recognition and machine learning** designing applications for solving specific problems.
- **Image recognition and classification.**
- **Kernel methods** in pattern recognition and machine learning**.**
- **Mathematical models of real phenomena in Fluid Mechanics:** heat transfer problems, transport in porous media problems, micropolar problems, nanofluids problems and also combined problems which include a porous matrix, a nanofluid and mixed convection conditions.

Nonlinear and Convex Analysis:

- **Equilibrium problems**: obtaining existence results for equilibrium problems and their particular cases (namely, optimization problems; complementarity problems; variational inequalities, saddle-point problems, Nash equilibria problems, fixed point problems); sensitivity analysis of solutions; studying well-posedness for equilibrium problems.
- **Optimization:** obtaining new optimality conditions for a large variety of problems; applying the results to duality theory.
- **Variational inequalities and equilibrium problems:** determining conditions for the existence of solutions, stability relative to problem data; identifying problems in technical sciences that can be modeled using variational inequalities.
- **Pseudomonotonicity properties of operators:** obtaining relations between different types of pseudomonotone operators.

Mathematical Programming/Optimization:

- **Numerical Optimization**: optimization methods used in the simulation of rigid body systems and granular matter, parallel algorithms for mathematical programs coming from applications such as image processing and autonomous navigation, complementarity based integration schemes used in the planning and control of autonomous tasks.
- **Stochastic Optimization**: theoretical aspects related to the convergence of approximation schemes, parallel algortihms used in obtaining the numerical solutions of the large, finite dimensional programs resulting from the approximation of the infinite dimensional problem.
- **Variational Inequalities:** applications of variational inequalties to stochastic programming, use of differential variational inequalities in describing rigid body dynamics subject to equality, inequality and complementarity constraints, stochastic complementarity problems and applications.

Team and key skills

Prof. Dr. Mat. Mircea Ivan is a highly experienced researcher and manager. He is the coordinator of multiple national research projects in the field of numerical analysis. His most important contributions cover the following topics from approximation theory: divided differences, positive linear operators, special functions, mean-value theorems, interpolation operators, asymptotic expansions, splines, and Bezier approximation. Prof. Mircea Ivan is the editor-in-chief of ACAM and ATPS. He published over 135 scientific papers, including 34 ISI journal papers and 20 books.
Prof. Dr. Mat. Ioan Gavrea has brought important scientific contributions in areas such as approximation theory, linear positive operators of Jackson type, orthogonal polynomials, quadrature formulas with high degree of exactness, and special functions. His scientific results were published in 120 papers, including 29 ISI journal papers.
Prof. Dr. Mat. Ioan Raşa is a highly experienced researcher in the fields of Probability Theory, Statistics and Functional Analysis. He published over 100 scientific papers, 45 of them being ISI journal papers. He authored/coauthored 10 books in the above mentioned fields. Prof. Rasa was Invited Speaker at several international conferences and Visiting Professor at several universities in Italy, Germany, Spain.
Prof. Dr. Mat. Alexandru Ioan Mitrea is a very experienced researcher and manager. He is the project manager of several interdisciplinary or fundamental research projects joining teams of medical specialists, computer scientists and mathematicians. His most important contributions cover topics from approximation theory, calculus of variations and numerical analysis applied in the theory of deformable models and medical imaging. He published over 100 scientific papers, including 21 ISI journal papers, Springer chapter-books, IEEE conference papers and 10 books.
Prof. Dr. Mat. Dorian Popa is an experienced researcher with significant contributions in the fields of Functional Equations, Hyers-Ulam Stability, Functional Inclusions, Generalized Convexity, Set-Valued Analysis and Ordinary Differential Equations. Prof. Dorian Popa has published over 80 scientific papers, including 29 papers in ISI journal. He acted as project coordinator or member for national and international grants in various domains of pure and applied mathematics.
Prof. Dr. Mat. Daniela Rosca, 22 papers published in ISI journals, 4 international grants, 10 Visiting Professor. Abilities: Wavelets, Discrete Mathematics, Image processing.
Assoc. Prof. Dr. Mat. Ioan Radu Peter has major field of research in global differential geometry and topology. He received several grants and postdoc fellowships (Japan, Hungary). His contributions are in positively curved manifolds, Morse theory, special producst of metrics on manifolds (warped, twisted). He has also interests in applying mathematics in other areas. He is involved in a team of a FP7 project (PAN-Robots), he is co-PI in DynAPSNeuro and he collaborates with a research team from MSKCC – New York (Memorial Sloan-Kettering Cancer Centre). In these projects he mainly designs machine learning and pattern recognition algorithms in specific problems.
Assoc. Prof. Dr. Math. Daniela Inoan has research interests in the field of Nonlinear and Convex Analysis, more precisely the study of variational inequalities, pseudomonotone operators, generalized convex functions. Her contributions were published in 23 papers and 9 books. She coordinated a research project (CNCSIS grant) and was also a member in the teams of 4 other research projects.
Assoc. Prof. Dr. Math Alina Sîntămărian is a researcher in the fields of multivalued operator theory and real analysis, obtaining results regarding the fixed point theory of multivalued operators and the evaluation of special constants. These

results were published in 2 books and 42 articles, including 8 articles published in ISI journals.
Assist. Prof. Dr. Math. Dalia Cimpean is a researcher specialized in Applied Mathematics and Fluid Mechanics. She obtained a Marie Curie PhD fellowship in fluid dynamics, was member in research projects, one NATO project, and obtained a Postdoc fellowship. Her contributions are important in Applied Mathematics, Differential Equations and Fluid Mechanics. She has published in more than 20 scientific journals (6 ISI), 3 books in English and she has registered several participations to International Conferences.
Assoc. Prof. Dr. Mat. Bogdan Ionuţ Gavrea obtained his PhD degree in Applied Mathematics from University of Maryland, Baltimore County. Upon graduation Dr. Gavrea has received a post-doctoral fellowship at GRASP Laboratory, University of Pennsylvania, one of the best robotics laboratories in the United States. Other research stays of Dr. Bogdan Gavrea were done at Argonne National Laboratory, USA and University of Heidelberg, Germany. Since 2007, he has been a member of the Department of Mathematics, Technical University of Cluj-Napoca. His research interests are in numerical analysis, optimization, simulation of rigid body systems, stochastic programming, parallel algorithms and mathematical inequalities. The applications that are targeted by Bogdan Gavrea's research include robotics, autonomous navigation and image processing.
Assoc. Prof. Dr. Math. Adela Novac has a 10 years experience in the field of differential equations, uniform spaces and fixed point theory. Her contributions were published in 5 ISI journal papers, 17 BDI papers and 4 books.
Assist. Prof. Dr. Mat. Mircea Dan Rus is a young researcher whose major field of research and main contributions are in fixed point theory, with emphasis on iterative fixed point approximation methods and their application. He has also interests and contributions in a wide area of topics like: combinatorics, partial differential equations, scattered data interpolation, optical flow estimation, and 3d shape reconstruction.
Assist. Prof. Dr. Mat. Ovidiu Furdui has published research articles in operator theory and special function theory. He is also interested, among others, in studying the properties of special constants that are in close connection to the Riemann zeta, Hurwitz zeta and the Polylogarithm functions.
Assist. Dr. Mat. Adrian Holhos is a researcher in in the field of numerical analysis. His contributions include results concerning the rate of approximation of unbounded functions by positive linear operators. They were published in 10 scientific papers, including two ISI journal papers.
Assist. Dr. Mat. Adela Capătă is a young researcher in the field of nonlinear analysis. Starting with 2006, she began her research activity, which is sprinkled with some research stages at the University of Pisa and the fellowship A.07/73196 of DAAD. Her contributions are in the topic of vector and multifunction equilibrium problems theory and optimization; and they are published in 6 ISI journal papers, 1 ISI proceeding paper, 4 BDI journal papers and one book.

Infrastructure

The research facilities of the Research Center for Applied Mathematics in Engineering Sciences of the Mathematics Department of the Technical University of Cluj-Napoca.

Development strategy

High quality research by:
- approaching open problems of significant interest for the scientific community and for the applied fields,
- development and integration of state of the art techniques and algorithms,
- training and involving young researchers in high level research projects,
- producing highly innovative results with an important impact in the scientific community,
- generalizing certain results by making use of weaker assumptions than those existent.

Representative projects

DynAPSNeur, "Dynamics Analysis of Parallel Simulations of Biological Neural Microcircuits", *FP7 "Research Infrastructures"* action (January 1 - December 30, 2013), belongs to the Computational Neuroscience research field. More precisely, the project investigates the impact of parallelization strategies on the dynamic behavior of biological neural microcircuit simulation. http://www.hp-see.eu/hp-see-pilot-call-awarded-applications.
MoDef, "Modelling using advanced methods and techniques based on the theory of deformable surfaces with applications in computer assisted surgery and other modelling procedures of anatomic structures" ;
PNII Partnership (2007-2010). Based on performing mathematical algorithms (involving convergence rate, consistency and stability conditions), which provide energy- minimizing surfaces, it was generated, in the context of the partnership, a software component made in Visual C++ (DotNet environment), aimed to implement 3D computerized model of the abdominal wall; http://dicomge.utcluj.ro/modef
"Advanced Methods and Algorithms of Mathematics related to the Theory of Deformable Models, with applications in image processing and medicine", *CNCSIS* (2006-2008) aimed to the study of the convergence, approximation error and stability of a class of new mathematical algorithms developed in order to find the energy-minimizing snakes, used in medical imaging,
"Denoising and compression of data on high-dimensional manifolds", *Deutsche Forschung Gemeinschaft* (January 1 - December 31, 2011), Bilateral cooperation Germania – Romania PL 170/14-1, Georg Austin University, Göttingen. The aim of the project is to derive new adaptive wavelet method for Datenapproximation in higher dimensions. In particular, focused on the construction of efficient algorithms in three-dimensional case as well as two-or three-dimensional manifolds in the foreground.
"Denoising and compression of spherical data", *Deutsche Forschung Gemeinschaft* (2007 –2010), Bilateral cooperation Germania – Romania 436 RUM 113/31/0-1, University of Duisburg-Essen. The project objective is

the derivation and analysis of new methods of filtering and compression of data on the sphere. Taking advantage of the known methods from the fields of variational methods, the non-linear diffusion and harmonic analysis, new hybrid method can be constructed that are especially suitable for data analysis and data filtering on the sphere.
DESPED, **"Stereo Based Object Tracking and Pedestrian Recognition in Traffic and Environments"**, *Wolkswagen AG*, Germania (2006-2007) (coord. professor Sergiu Nedevschi).
DESBOR, **"Recognition system for automatic cruise control in urban traffic environments",** *Volkswagen AG*, Germania (2005-2007) (coord. professor Sergiu Nedevschi).
CRIOLAPSIM, **"Laparoscopic Cryosurgical Treatment of the renal tumors individualized using simulations on 3D reconstructed model"**, *CEEX* (2006-2008) director TUCN prof. dr. ing. Sergiu Nedevschi (in cooperation with "Institutul Clinic de Urologie şi Transplant Renal" Cluj-Napoca.

Significant results

Articles in ISI rated journals, in the past 5 years:

2013

1. U. Abel, M. Ivan, Complete asymptotic expansions for Altomare operators. *Mediterr. J. Math.* 10 (2013), no. 1, 17–29.
2. U. Abel, M. Ivan, R. Păltănea, Geometric series of Bernstein operators revisited. *J. Math. Anal. Appl.* 400 (2013), no. 1, 22–24.
3. A. Capătă, Optimality conditions for vector equilibrium problems and their applications. *J. Ind. Manag. Optim*. 9 (2013), no. 3, 659–669.
4. A.E. Capătă, Existence theorems for vector equilibrium problems via quasi-relative interior, *The Scientific World Journal,* vol. 2013(2013), Article ID 150130, 6 pages.
5. D. Cárdenas-Morales, P. Garrancho, I. Raşa, Optimality of piecewise τ-linear interpolating operators, *Applied Mathematics and Computation* 219 (2013), 6445–6448.
6. O. Furdui, A class of fractional part integrals, *Integral Transforms Spec. Funct.* 24, (2013), no. 6, 485–490.
7. I. Gavrea, M. Ivan, Optimal rate of convergence for sequences of a prescribed form. *J. Math. Anal. Appl*. 402 (2013), no. 1, 35–43.
8. I. Gavrea, M. Ivan, A solution to an open problem on the Euler–Mascheroni constant. *Appl. Math. Comput*. 224 (2013), 54–57.
9. I. Gavrea, G. Tachev, On the multiplicativity of linear operators. *J. Math. Anal. Appl.* 408 (2013), no. 1, 203–208.
10. I. Gavrea, On Butzer's problem. *Appl. Anal.* 90 (2011), no. 3-4, 417–429.
11. H. Gonska, I. Rasa, On infinite products of positive linear operators reproducing linear functions, *Positivity* 17 (2013), No. 1, 67–79.
12. H. Gonska, I. Rasa, M. Rusu, Cebysev-Gruss-Type Inequalities Revisited, *Math. Slovaca* 63 (2013), no. 5, 1007–1024
13. D. Inoan, I. Raşa, A recursive algorithm for Bernstein operators of second kind. *Numer. Algorithms* 64 (2013), no. 4, 699–706.
14. A.I. Mitrea, On the unbounded divergence in the best approximation on equidistant nodes. *Appl. Math. Lett.* 26, (2013), no.1, 61–64
15. I. R. Peter, D. Popa, Stability of points in mean value theorems, *Publ. Math. Debrecen*, Publ. Math. Debrecen, 83 (2013), no 3, 375–384.
16. T. Peter, G. Plonka, D. Roşca, Representation of sparse Legendre expansions. *J. Symbolic Comput*. 50 (2013), 159–169.
17. D. Popa, I. Raşa, On the stability of some classical operators from approximation theory. *Expo. Math.* 31 (2013), no. 3, 205–214.
18. I. Rasa, Asymptotic relations for the Bernstein-Schnabl operators on the unit interval, *Carpathian J. Math*. 29 (2013), no. 1, 85–89.
19. D. Rosca, M. De Graef, Area-preserving projections from hexagonal and triangular domains to the sphere and applications to electron back-scatter diffraction pattern simulations, *Modelling Simul. Mater. Sci. Eng.* 21 (2013), 1–17.
20. Rus, Mircea Dan. Optimization methods for l^1-energy minimization in the estimation of optical flow. *Carpathian J. Math.* 29 (2013), no. 1, 109–117.

2012

21. A. Capătă, Optimality conditions for extended Ky Fan inequality with cone and affine constraints and their applications. *J. Optim. Theory Appl*. 152 (2012), no. 3, 661–674.
22. D.S. Cimpean, I. Pop, Fully developed mixed convection flow of a nanofluid through an inclined channel filled with a porous medium, *Int. J. Heat Mass Transfer*, 55 (2012), 907–914.
23. G. Bigi, A. Capătă, G. Kassay, Existence results for strong vector equilibrium problems and their applications. *Optimization* 61 (2012), no. 5, 567–583.
24. B. Gavrea, Improvement of some inequalities of Chebysev-Grüss type. *Comput. Math. Appl.* 64 (2012), no. 6, 2003–2010.
25. A. Holhoş, Uniform approximation of functions by Meyer-König and Zeller operators. *J. Math. Anal. Appl*. 393 (2012), no. 1, 33–37.

26. D. Inoan, I. Raşa, A majorization inequality for Wright-convex functions revisited. *Aequationes Math*. 83 (2012), no. 3, 209–214.
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28. A. I. Mitrea, Double condensation of singularities for product-quadrature formulas with differentiable functions. *Carpathian J. Math*. 28 (2012), no. 1, 83–91.
29. A. I. Mitrea, R. Badea, D. Mitrea, S. Nedevschi, P. Mitrea, D. M. Ivan, O. M. Gurzău, Iterative methods for obtaining energy-minimizing parametric snakes with applications to medical imaging. *Comput. Math. Methods Med.* 2012, Art. ID 918510, 11 pp.
30. D. Popa, I. Raşa, On the Hyers-Ulam stability of the linear differential equation. *J. Math. Anal. Appl*. 381 (2011), no. 2, 530–537.
31. D. Popa, I. Raşa, The Fréchet functional equation with application to the stability of certain operators. *J. Approx. Theory* 164 (2012), no. 1, 138–144.
32. N. Lungu, D. Popa, Hyers-Ulam stability of a first order partial differential equation. *J. Math. Anal. Appl.* 385 (2012), no. 1, 86–91.
33. N. Lungu, D. Popa, On the Hyers-Ulam stability of a first order partial differential equation. *Carpathian J. Math.* 28 (2012), no. 1, 77–82.
34. A. Ciurte, S. Nedevschi, I. Raşa, An algorithm for solving some nonlinear systems with applications to extremum problems. *Taiwanese J. Math*. 16 (2012), no. 3, 1137–1150.
35. D. Cárdenas-Morales, P. Garrancho, I. Raşa, Asymptotic formulae via a Korovkin-type result. *Abstr. Appl. Anal.* 2012, Art. ID 217464, 12 pp.
36. H. Gonska, I. Raşa, M-R. Rusu, Applications of an Ostrowski-type inequality. *J. Comput. Anal. Appl.* 14 (2012), no. 1, 19–31.
37. I. Raşa, Estimates for the semigroup associated with Bernstein-Schnabl operators. *Carpathian J. Math.* 28 (2012), no. 1, 157–162.
38. I. Raşa, Power series of Bernstein operators and approximation of resolvents. *Mediterr. J. Math.* 9 (2012), no. 4, 635–644.
39. D. Roşca, G. Plonka, An area preserving projection from the regular octahedron to the sphere. *Results Math.* 62 (2012), no. 3-4, 429–444.
40. D. Roşca, Generalized orthonormal piecewise constant wavelet bases with 1–4 splitting. *Int. J. Wavelets Multiresolut. Inf. Process.* 10 (2012), no. 1, 1250001, 10 pp.
41. A. Sîntămărian, Some new sequences that converge to a generalized Euler constant. *Appl. Math. Lett.* 25 (2012), no. 6, 941–945.

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43. A. Capătă, G. Kassay, B. Mosoni, On weak multifunction equilibrium problems. Variational analysis and generalized differentiation in optimization and control, 133–148, *Springer Optim. Appl.,* 47, Springer, New York, 2010.
44. A. Capătă, G. Kassay, On vector equilibrium problems and applications. *Taiwanese J. Math*. 15 (2011), no. 1, 365–380.
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46. D. J. Cappelleri, P. Cheng, J. Fink, B. Gavrea, V. Kumar, Automated Assembly for Mesoscale Parts, *IEEE Tran. Automation Science and Engineering,* 8(3), 598–613, 2011.
47. I. Gavrea, M. Ivan, On the iterates of positive linear operators. *J. Approx. Theory* 163 (2011), no. 9, 1076–1079.
48. I. Gavrea, M. Ivan, The iterates of positive linear operators preserving constants. *Appl. Math. Lett.* 24 (2011), no. 12, 2068–2071.
49. U. Abel, M. Ivan, New representation of the remainder in the Bernstein approximation. *J. Math. Anal. Appl.* 381 (2011), no. 2, 952–956.
50. U. Abel, M. Ivan, The Bleimann-Butzer-Hahn operators: old and new results. *Appl. Anal.* 90 (2011), no. 3-4, 483–491.
51. A. Chiş-Novac, Data dependence of fixed points in gauge spaces. *Fixed Point Theory* 12 (2011), no. 1, 49–56.
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54. D. S. Cîmpean, D. Popa, Hyers-Ulam stability of Euler's equation. *Appl. Math. Lett.* 24 (2011), no. 9, 1539–1543.
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65. G. Plonka, S. Tenorth, D. Roşca, A new hybrid method for image approximation using the easy path wavelet transform. *IEEE Trans. Image Process.* 20 (2011), no. 2, 372–381.
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The offer addressed to the economic environment

Research & development in core areas	Development of original solutions for modelling dynamic 3D environments. - Development of numerical algorithms for stochastic programming problems arising from application fields such as robotics and energy systems.
Research & development in applied fiels	Development of real-time perception systems for structured or unstructured 3D environments, applied to driving assistance systems, autonomous robots, space observation, or computer assisted medical diagnosis. - Development of simulation and planning software modules with direct application in robotics and autonomous navigation. - Development of state of the art solution using pattern recognition and machine learning for specific problems.
Consulting	Consulting, design, research in pattern recognition, machine learning for multiple industrial and scientific fields.
Training	**Image processing basics:** Image processing algorithms and techniques, pattern recognition, machine learning, kernel methods with applications in different fields (computer vision, neuroscience, medical, speech recognition) Numerical optimization algorithms, time stepping schemes for rigid body systems with applications to robotics, autonomous navigation and granular materials.