**Name:** Prof. Gábor Szederkényi
**Date and place of birth:** 21 April 1975, Mór, Hungary

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MTMT (Hungarian official publication database) link:
https://vm.mtmt.hu//search/slist.php?lang=0&AuthorID=10000614

**Current position**

*full professor,* Faculty of Information Technology and Bionics (ITK), Péter Pázmány Catholic University (PPKE), Budapest, Hungary, 2013-

*scientific advisor,* (part-time), Process Control Research Group, Computer and Automation Research Institute, Hungarian Academy of Sciences (MTA SZTAKI), Budapest, Hungary, 2014-

**Degrees**

*MSc in Information Technology,* Faculty of Engineering, University of Veszprém, Hungary, 1998

*PhD in Information Science,* University of Veszprém, Hungary, 2002 (Dissertation: Grey-box approach for the diagnosis, analysis and control of nonlinear process systems)

*PhD* University of Vigo, Spain, 2011 (Hungarian PhD degree accepted and homologated)

*DSc in Engineering Sciences,* Hungarian Academy of Sciences, 2013

**Professional experience**

*assistant researcher,* Systems and Control Laboratory, MTA SZTAKI, 1998-2001

*researcher,* Systems and Control Laboratory, MTA SZTAKI, 2001-2002

*senior researcher,* Process Control Research Group, MTA SZTAKI, 2003-2013

*lecturer,* Faculty of Information Technology, PPKE, 2004-2006

*associate professor* (part-time), Faculty of Information Technology, PPKE, 2006-2013

*visiting researcher,* (Bio)Process Engineering Group, CSIC Marine Research Institute, Vigo, Spain, Jan. – Dec. 2011

**Languages**

English: fluent, intermediate state exam (no. 928464/1991)
Russian: reading, intermediate state exam (no. 019696/1993)
Hungarian: mother tongue

**Teaching activity at PPKE-ITK**

*Computer Controlled Systems* (lecturer), 2004-present

*System Identification* (lecturer), 2004-present

*Robotics* (co-lecturer with Dr. Gy. Cserey), 2006-present

*Analysis and Control of Nonlinear Molecular Processes* (co-lecturer with Dr. Dávid Csercsik), 2013-

*Linear Algebra* (teaching assistant), 2001-2002

**Other courses taught**

*Analysis and Control of Nonlinear Process Systems* (teaching assistant, lecturer: Prof. K.M. Hangos), intensive PhD course, Technical University of Denmark, Lyngby, 2000

*Advanced Nonlinear Control Design Methods* (co-lecturer with Prof. K.M. Hangos) University of Veszprém 2003, Budapest University of Technology and Economics 2005-2006, University of Pannonia 2012, 2014, 2016

*Calculus* (teaching assistant), Budapest University of Technology and Economics, 2004

**Student mentoring**

*supervising BSC and MSc students:* Zoltán Soós (Computer Engineering MSc, University of Pannonia), Gábor Faludi (Computer Engineering MSc, PPKE, 2010), Zoltán A. Tuza (Computer Engineering MSc with honors, PPKE, 2010), János Rudan (Computer Engineering MSc, PPKE, 2010), Gergely

Józsa (Computer Engineering MSc, PPKE, 2010), András Tóth (Computer Engineering MSc with honors, PPKE, 2010), Ilona Sonnevend (Computer Engineering BSc, PPKE, 2010), Ágnes Csenge Pop (Computer Engineering BSc, PPKE, 2012), Jose Eduardo Silva Arellano (Nonlinear Control Systems MSc, University of Colima, Mexico, co-supervised), Eszter Tilesch (Info-Bionics MSc, PPKE, 2014), András Hild (Info-Bionics MSc, PPKE, 2014), Domokos Meszéna (Info-Bionics MSc, PPKE, 2014), AttilaSchulc (Comuter Engineering BSc, 2015), Felicián Benda (Computer Engineering BSc, 2015), Gábor Majoros (Computer Engineering BSc, 2015), Gergely Szlobodnyik (Molecular Bionics BSc, 2015), Péter Polcz (Computer Engineering MSc, 2016)

*supervising research projects of students (TDK):* Attila Magyar (University of Pannonia, 2015), Antal A. Sándor (PPKE, 2009), Zoltán A. Tuza (PPKE, 2010), János Rudan (PPKE, 2010), Ilona Sonnevend (PPKE, 2010), Domokos Meszéna (PPKE, 2015), Péter Polcz (PPKE, 2015), Gergely Sváb (PPKE-SOTE, 2016), Gergely Szlobodnyik (PPKE, 2016)

**PhD graduates**

Barna Pongrácz (co-supervised), PhD 2008, University of Pannonia, evaluation: summa cum laude
Dávid Csercsik (co-supervised), PhD 2010, PPKE, evaluation: summa cum laude
János Rudan (co-supervised), PhD, 2014, PPKE, evaluation: summa cum laude
Zoltán A. Tuza, PhD, 2015, PPKE, evaluation: summa cum laude

**Current PhD students**

Bernadett Ács PPKE, expected graduation: 2017
György Lipták (co-supervised), University of Pannonia, expected graduation: 2018
Péter Polcz, PPKE, expected graduation: 2020

**Cooperation with young researchers**

Piroska Ailer, PhD 2003, Budapest University of Technology and Economics (2 joint journal papers, 8 joint conference papers)
Csaba Fazekas, PhD 2008, University of Pannonia (3 joint journal papers, 7 joint conference papers)
Attila Magyar, PhD 2008, University of Pannonia (2 joint journal papers, 4 joint conference papers)
Matthew D. Johnston, PhD 2011, University of Waterloo, Canada (3 joint journal papers, 1 joint conference paper)
Irene Otero Muras, PhD 2010, University of Vigo, Spain (2 joint journal papers, 4 joint conference papers)
Attila Gábor, PhD thesis submitted, University of Pannonia (4 joint journal papers, 2 joint conference papers)

**Refereeing for journals and conferences**

Regular refereeing e.g. for IEEE Tr. on Automatic Control, Automatica, Systems & Control Letters, Journal of Process Control, Mechanism and Machine Theory, Archives in Advanced Mechanics, Journal of Mathematical Chemistry, MATCH Communications in Mathematical and in Computer Chemistry, BMC Systems Biology, Bioinformatics, PLOS ONE, and major conferences in the field of modeling, identification and control such as the IFAC World Congress, IEEE Conference on Decision and Control, and IFAC NOLCOS.

**Participation in scientific evaluation**

*PhD reviews:* 9 (PPKE, University of Pannonia, Budapest University of Technology and Economics)
*Memberships in PhD defense committees:* 6 (PPKE, University of Pannonia, Budapest University of Technology and Economics)
*Memberships in habilitation committees:* 2 (Óbuda University, Budapest University of Technology and Economics)
*Reviewer in habilitation process:* 1 (University of Pannonia)
*Reviewer in DSc process:* 1 (Hungarian Academy of Sciences)
*Committe member in DSc process:* 1 (Hungarian Academy of Sciences)
*Examiner at PhD final exams:* 3 (University of Pannonia)

**Evaluation of scientific works and research proposals**

Hungarian Scientific Research Fund, grant reviewer, 2007-2010
Hungarian National Excellence Program, reviewer, 2012, 2016
AMS MathReviews, reviewer, 2010-
Slovenian Research Agency, grant reviewer, 2015
Austrian Research Agency, grant reviewer, 2015
European Research Council, external reviewer for Starting Grant proposals, 2014

**Professional memberships and responsibilities**

secretary of IEEE Hungary Section between 2010-2016
member of the IEEE Control Systems Society since 2007
member of the public body of the Hungarian Academy of Sciences since 2002
member of the Informatics Committee of the Hungarian Academy of Sciences since 2014
internal member of the Roska Tamás PhD School of Science and Engineering at PPKE since 2009
member of the Disciplinary Doctoral and Habilitation Committee of PPKE-ITK since 2013
external member of the Information Science PhD School of the University of Pannonia since 2015

**Editorial board memberships in international journals**

editorial board member of MATCH Communications in Mathematical and in Computer Chemistry since 2011
editorial board member of the Journal of Industrial Engineering since 2012

**Awards and scholarships**

Scholarship of the Hungarian Republic for outstanding university results, 1996-1997
M.Sc. diploma with honors, University of Veszprém,1998
2nd and 1st prize of the PhD students' conference of the institute, MTA SZTAKI, 1999, 2000
Institutional Award of MTA SZTAKI, 2000, 2002, 2006, 2008
Scientific Publication Award of MTA SZTAKI, 2003, 2009, 2012, 2015
Bolyai János Research Scholarship of the Hungarian Academy of Sciences, 2003-2006
topic: Analysis of nonlinear process systems for control and diagnosis, final evaluation: outstanding (highest rank)
Bolyai János Research Scholarship of the Hungarian Academy of Sciences, 2007-2010
topic: Analysis and control of biochemically or biologically motivated nonlinear dynamical systems
Youth Award of the Hungarian Academy of Sciences, 2007 (work: Participation in the design and implementation of the primary loop pressure controller at the Paks Nuclear Power Plant)

**Important national and international scientific projects**

In the forthcoming list, the titles of the selected projects are typeset with boldface-italic and only these contain a more detailed description.

***Role in national research projects***

(i) *Diagnosis and control of nonlinear process systems (2000-2002), Modeling and control of dynamic process systems (2003-2006)* (Hungarian Scientific Research Fund, role: participating researcher)

(ii) ***Analysis based control of nonlinear systems*** (2004-2007) (Hungarian Scientific Research Fund, role: principal investigator, budget: 4.2 million HUF) The aim of this basic research project was to conduct an interdisciplinary research in the field of analysis and control of nonlinear dynamical systems. The main scientific results were the following. Using graph-theoretical algorithms, a method was proposed for the appropriate design of model reduction steps to obtain a reduced model with differential index 1. It was shown that the global stability of quasi-polynomial (QP) and related Lotka-Volterra models is equivalent to the existence of a local dissipative-Hamiltonian description of the system around the equilibrium point. It was shown that the global stability analysis of QP systems using an entropy-like Lyapunov function candidate and a state-dependent time-scaling transformation leads to the solution of a suitably constructed bilinear matrix inequality. An effective algorithm was developed for retreiving a wide class of invariants from the differential equations of QP systems.

A globally stabilizing feedback controller design method based on the iterative solution of linear matrix inequalities was proposed for process system models.

(iii) *Design and development of a decision support expert system at the 400/120 kV switching station of the Paks Nuclear Power Plant, Hungary (1998-2000)*

(iv) *Analysis of the pressure control loop of the primary circuit at the Paks Nuclear Power Plant, Hungary (2004)*

(v) ***Design and implementation of the primary circuit pressure control loop at the Paks Nuclear Power Plant, Hungary*** *(2005-2006)* The aim of this project was the design and implementation of an advanced controller that is capable of precisely stabilizing the pressure of the primary circuit of the power plant in a 0.1 bar range. The replaced old controllers produced pressure oscillations with an amplitude of approximately 1 bar during normal operation. These oscillations were undesirable from the point of view of equipment deterioration. Moreover, the thermal power capacity of the units could not be utilized optimally with the outdated controllers. The research group that consisted of two coordinating professors and four senior researchers (with PhD) developed a model-based dynamic inversion controller. The implemented controller has a redundant distributed structure including measurement and control devices, a continuous power controller and a special supervisory module. The developed controllers are now running very successfully on all four units of the nuclear power plant. The successful project largely supported that the originally 440 MW units are now safely operating at 500 MW. My tasks were the identification of the pressurizer from measurement data using a physical model, and the actual coding of the control algorithm on PLC. Moreover, I proved that the controller keeps the required performance and closed loop stability even if some data packets are delayed or lost in the networked environment. This project was a unique opportunity to take part in a teamwork that included the whole design and implementation process for a really mission-critical application using the latest scientific results. For this work, I obtained the Youth Prize of the Hungarian Academy of Sciences together with three colleagues in 2007.

(vi) *Analysis of the primary circuit control loops at the Paks Nuclear Power Plant, Hungary (2007-2008)*

(vii) *Model-based analysis and diagnosis of nonlinear systems using first principles (2011-2015)* (Hungarian Scientific Research Fund, role: participating senior researcher)

(viii) ***Analysis and control of polynomial nonlinear systems using optimization methods*** *(2012-2016)* (Hungarian Scientific Research Fund, role: principal investigator, budget: 50.5 million HUF) The overall aim of the project was to develop model analysis, identification and controller design methods for nonlinear dynamical systems using the special advantageous algebraic structures of two related system classes with good descriptive power: quasi-polynomial (QP) systems and deterministic kinetic systems. Optimization methods were used as tools of key importance for the solution of the emerging algebraically complex problems. The key results are the following: 1) As a solution for an important inverse problem, an optimization-based computational method was given to compute deficiency zero realizations of kinetic systems given in the form of ordinary differential equations. 2) We gave an algorithm to determine all possible structurally different linearly conjugate realizations of a given kinetic polynomial system. 3) The set of equilibrium solutions of weakly reversible kinetic models was explored through a novel factorization of the kernel of the system equations. 4) The previously constructed computational framework for analyzing directed graph structures of polynomial kinetic systems was extended to nonnegative models containing rational terms. 5) We gave a computational solution to the feedback equivalence problem for kinetic systems.

***Experience in international scientific collaboration***

(viii) *Qualitative and analytical model based fault detection for chemical processes, EU Copernicus Project CT94-237 (1995-1998)*

(ix) ***Analysis and control of complex nonlinear process systems*** *(2003-2006): bilateral research project between the Hungarian Academy of Sciences and the Spanish Ministry of Education and Science*

The aim of this collaborative work between the Process Engineering Group of the Marine Research Institute in Vigo, Spain and the Process Control Research Group of MTA SZTAKI was to connect

thermodynamics and reaction kinetics to analyze basic system properties for process systems. The project supported mutual short visits (approximately 3-4 weeks/person/year) of the researchers between Spain and Hungary. G. Szederkényi began to study the dynamic models of reaction networks through this project and this cooperation initiated the idea to try to use the reaction kinetic model class in other fields and to study its relation to the previously investigated quasi-polynomial systems. The following main results were obtained from this joint work. Based on a generalized description of biochemical systems, a physically motivated storage function was constructed and used for stability analysis and controller design. The Hamiltonian system description known from classical mechanics was connected to the dynamical description of reaction networks with independent elementary reactions. Optimization based on Mixed Integer Linear Programming was used for constructing reaction networks with given properties. An invited book chapter was written partially using the results obtained of the framework of the project.

(x) *Computer-aided food processes for control (CAFE), FP7-212754* (2008-2012): The objective of the CAFE project was to provide new paradigms for the smart control of food processes, on the basis of four typical processes in the areas of bioconversion, separation, preservation and structuring. My task was to do theoretical research on biochemical reaction networks in the framework of the project during the year 2011 in IIM-CSIC in Spain.

(xi) *Analysis, diagnosis and control of distributed nonlinear process systems (2006-2007): bilateral research project in the framework of the Hungarian-Slovenian Intergovernmental S&T Cooperation Programme*

**Invited lectures/presentations at conferences and research institutes**

European Control Conference, Karlsruhe, Germany (1999)
Nordic Process Control Workshop, Lyngby, Denmark (2000)
Institute of Information Theory and Automation, Prague, Czech Republic (2002)
International Computer Aided Process Engineering Forum, Veszprém, Hungary (2004)
Jozef Stefan Institute, Ljubljana, Slovenia (2004)
Marine Research Institute, Vigo, Spain (2005, 2006)
Workshop on System Identification and Control Systems, Budapest, Hungary (2006)
NSF Workshop on Real Time Control of Hybrid Systems, Budapest, Hungary (2007)
International Conference on the Theory and Applications of Differential Equations, Veszprém, Hungary (2007)
Workshop of Systems & Control Theory, Budapest, Hungary (2008)
9th International PhD Workshop on Systems and Control (plenary speaker), Izola, Slovenia (2008)
European Control Conference, Budapest, Hungary (2008)
Coping with Complexity: Model Reduction and Data Analysis, Research Workshop, Ambleside, UK (2009)
8th European Conference on Mathematical and Theoretical Biology, Krakow, Poland (2011)
SIAM Conference on the Life Sciences, San Diego, USA (2012)
Mathematical Modeling Seminar, Budapest University of Technology and Economics (2014)
Chalmers University, Department of Signals and Systems (2014)
Formal Reaction Kinetics Seminar, Budapest University of Technology and Economics (2013, 2014, 2015)
International Workshop on Reaction Kinetics, Budapest University of Technology and Economics (2016)

**Research topics and interests**

analysis and control of nonlinear dynamical systems; identifiability analysis and parameter estimation; computational analysis and synthesis of biological system models

**Main scientific result**

I have proposed a new computational approach combining computer science and systems theory for the kinetic realization problem of a wide class of nonlinear dynamical systems. This approach forms the basis of new model analysis and controller design techniques for which I proposed computationally efficient solutions in an optimization framework. This framework allowed to obtain the following results,

too: I have shown the existence and uniqueness of a super-structure containing all possible reaction graphs for kinetic models, and I have given polynomial-time algorithms to compute it. Using the super-structure property, with co-authors I have given the first algorithm in the literature to compute all possible reaction graph structures realizing a kinetic dynamics. Moreover, a bio-inspired feedback design method was proposed, where the controller parameters and the graph structure of the closed-loop system is computed in one optimization step.

**Erdős number:** 2, through four joint journal papers with Prof. Zsolt Tuza

## 5 most important publications

[1] I. Otero-Muras, G. Szederkényi, A.A. Alonso, and K.M. Hangos. Local dissipative Hamiltonian description of reversible reaction networks. *Systems and Control Letters*, 57:554–560, 2008. (G. Szederkényi is corresponding author).

[2] G. Szederkényi. Computing sparse and dense realizations of reaction kinetic systems. *Journal of Mathematical Chemistry*, 47:551–568, 2010. DOI: 10.1007/s10910-009-9525-5.

[3] G. Szederkényi, J. R. Banga, and A. A. Alonso. Inference of complex biological networks: distinguishability issues and optimization-based solutions. *BMC Systems Biology*, 5:177, 2011.

[4] B. Ács, G. Szederkényi, Zs. Tuza, and Z.A. Tuza. Computing all possible graph structures describing linearly conjugate realizations of kinetic systems. *Computer Physics Communications*, 204:11–20, 2016. (G. Szederkényi is corresponding author).

[5] K. M. Hangos, J. Bokor, and G. Szederkényi. *Analysis and Control of Nonlinear Process Systems*. Springer, 2004.