ACTIVITY REPORT 2010

PROCESS CONTROL RESEARCH GROUP

K. M. Hangos, D. Csercsik, G. Szederkényi
(group members)

I. T. Cameron, Cs. Fazekas, A. Gábor, R. Lakner, A. Magyar, E. Németh,
Sz. Rozgonyi (external members)

The activity of the group is focused primarily on modelling, analysis, diagnosis and control of nonlinear process systems with an emphasis on the use of underlying engineering, physical, biological and chemical principles.

Realization theory of reaction kinetic systems

Chemical Reaction Networks (CRNs) form a wide class of positive (or nonnegative) systems attracting significant attention not only among chemists but in numerous other fields such as physics, or even pure and applied mathematics where nonlinear dynamical systems are considered. Beside pure chemical reactions, CRNs are often used to model the dynamics of intracellular processes, metabolic or cell signalling pathways. The use of this theory on modelling of rapid and slow transmission in cell signaling pathways is described in [2].

Based on the structure of kinetic realizations, valuable information can be obtained about the dynamical properties of the investigated systems using the results of chemical reaction network theory (CRNT). Since the realizations of a given system can have many different structures, mixed integer linear programming is used to generate the ones with minimal/maximal number of reactions or complexes [7]. The effect of engineeering model reduction transformation on the dynamical properties of reaction kinetic networks with mass action law has been analyzed in [3].

Modelling and model analysis of GnRH neurons

A Hodgkin-Huxley type.nonlinear electrical circuit-analogue model has been developed for GnRH neurons [1], that play a central role in regulating the dynamic behaviour of the female reproductive cycle. The parameters of the model have been determined using patch clamp measured data in cooperation with the Neuroendrokinological Laboratory of KOKI. The identifiablity analysis of this model has also been performed [10]. Furthermore, an impulsive version of the model has also been developed [9] that is able to describe the bursting behaviour of GnRH neurons.

A PhD thesis has also been successfully developed in this area.

PUBLICATIONS-2010

Journal Papers

1. CSERCSIK, D.; FARKAS, I.; SZEDERKÉNYI, G.; HRABOVSZKY, E.; LIPOSITS, Z. AND HANGOS, K. M. (2010), 'Hodgkin–Huxley type modelling and parameter estimation of GnRH neurons', *Biosystems* **100**, 198-207.
impact factor: 1.267 (2009)

2. CSERCSIK, D.; SZEDERKÉNYI, G. AND HANGOS, K. M. (2010), 'Modelling of Rapid and Slow Transmission Using the Theory of Reaction Kinetic Networks', *ERCIM News* **82**, 22--23.

3. Hangos, K. M. (2010), 'Engineering Model Reduction and Entropy-based Lyapunov Functions in Chemical Reaction Kinetics', *Entropy* **12**, 772-797.
impact factor: 1.400 (2009*)

4. NÉMETH, E.; HANGOS, K. M. AND LAKNER, R. (2010), 'A procedure ontology for advanced diagnosis of process systems', *Journal of Intelligent and Fuzzy Systems* **21**, 19--31.
impact factor: 0.740 (2009)

5. ROZGONYI, S.; HANGOS, K. M. AND SZEDERKÉNYI, G. (2010), 'Determining the domain of attraction of hybrid non-linear systems using maximal Lyapunov functions', *Kybernetika* **46**, 19-37.
impact factor: 0.445 (2009)

6. SZABÓ, Z.; SZEDERKÉNYI, G.; GÁSPÁR, P.; VARGA, I.; HANGOS, K. M. AND BOKOR, J. (2010), 'Identification and dynamic inversion-based control of a pressurizer at the Paks NPP', *Control Engineering Practice* **18**, 554-565.
impact factor: 1.943 (2009)

7. SZEDERKÉNYI, G. (2010), 'Computing sparse and dense realizations of reaction kinetic systems', *Journal of Mathematical Chemistry* **47**, 551-568.
impact factor: 1.381 (2009)

Conference Proceedings

8. BALLÓ, G.; MAGYAR, A. AND HANGOS, K. M. (2010), 'Parameter estimation of quantum processes using convex optimization', *Proceedings of the 19th International Symposium on Mathematical Theory of Networks and Systems – MTNS 2010*, 5–9 July, 2010, Budapest, Hungary', 2043-2050. (ISBN 978-963-311-370-7).

9. CSERCSIK, D. (2010), 'Impulsive model of bursting GnRH neurons", *11th International PhD Workshop on Systems and Control a Young Generation Viewpoint*, September 1–3, 2010, Veszprém, Hungary', 20-25

10. CSERCSIK, D.; SZEDERKÉNYI, G. AND HANGOS, K. M. (2010), 'Identifiability of a Hodgkin-Huxley type ion channel under voltage step measurement conditions'(MoAT3.4), *in* M. Kothare; M. Tade; A. Vande Wouwer and I. Smets, ed*., '9th International Symposium on Dynamics and Control of Process Systems - DYCOPS 2010*, Leuven, Belgium, July 5-7', IFAC, 318-323.

11. FODOR, A.; MAGYAR, A. AND HANGOS, K. M. (2010), 'Dynamic Modeling and Model Analysis of a Large Industrial Synchronous Generator, *'IEEE Applied Electronics Conference'*, 8-9 Sept. 2010, Pilsen, INSPEC Accession Number: 11579485, IEEE, 1-6.

12. FODOR, A.; MAGYAR, A. AND HANGOS, K. M. (2010), 'Parameter Sensitivity Analysis of an Industrial Synchronous Generator ", *11th International PhD Workshop on Systems and Control a Young Generation Viewpoint*, September 1–3, 2010, Veszprém, Hungary', 2-10.

13. GÁBOR, A.; HANGOS, K. M. AND SZEDERKÉNYI, G. (2010), 'Modeling and Identification of the Pressurizer of a VVER Nuclear Reactor for Controller Design Purposes "*, 11th International PhD Workshop on Systems and Control a Young Generation Viewpoint*, September 1–3, 2010, Veszprém, Hungary', 11-19.

14. GÖRBE, P.; MAGYAR, A. AND HANGOS, K. (2010), 'Power Conditioning with Electric Car Battery Charging from Renewable Sources', *11th International PhD Workshop on Systems and Control a Young Generation Viewpoint*, September 1–3, 2010, Veszprém, Hungary', 98-105.

15. GÖRBE, P.; MAGYAR, A. AND HANGOS, K. M. (2010), 'THD Reduction with Grid Synchronized Inverter's Power Injection of Renewable Sources', 'SPEEDAM 2010*, International Symposium on*

Power Electronics, Electrical Drives, Automation and Motion', IEEE, 1381-1386, (ISBN 978-1-4244-7919-1/10/).

16. HANGOS, K. M.; NÉMETH, E.; LAKNER, R. AND TÓTH, A. (2010), 'Detectability and diagnosability of faults in lumped process systems', *in* S. Pierucci and G. Buzzi Ferraris, ed., *'20th European Symposium on Computer Aided Process Engineering – ESCAPE20*', Elsevier, 1447-1452.

17. RUDAN, J.; TUZA, Z. AND SZEDERKÉNYI, G. (2010), 'Using LMS-100 laser rangefinder for indoor metric map building' ,*'IEEE International Symposium on Industrial Electronics - ISIE 2010*, Bari, Italy, 4-7 July', 525-530, (ISBN 978-1-4244-6391-6/10).

18. RUPPERT, L. AND HANGOS, K. M. (2010), 'Martingale approach in quantum state estimation using indirect measurements', *'Proceedings of the 19th International Symposium on Mathematical Theory of Networks and Systems – MTNS 2010*, 5–9 July, 2010, Budapest, Hungary', 2049-2054, (ISBN 978-963-311-370-7).

19. SELIGMANN, B.; NÉMETH, E.; HOCKINGS, K.; O'BRIEN, C.; HANGOS, K. M. AND CAMERON, I. T. (2010), 'A Structured, Blended Hazard Identification Framework of Advanced Process Diagnosis', *13th International Symposium on Loss Prevention and Safety Promotion in the Process industries (Loss Prevention 2010)*, Brugge (BE), June 06 – 09, 2010', WE-21-4, 1-8..

20. SZEDERKÉNYI, G.; HANGOS, K.M. AND CSERCSIK, D. (2010), Computing Realizations of Reaction Kinetic Networks with Given Properties, *in* A. N. Gorban and D. Roose, ed., *'Coping with Complexity: Model Reduction and Data Analysis*', Springer, , pp. 253-267.

21. SZEDERKÉNYI, G. (2010), 'Computing reaction kinetic realizations of positive nonlinear systems using mixed integer programming', *8th IFAC Symposium on Nonlinear Control Systems - NOLCOS 2010*, Bologna, Italy, 1-3 September', ThP04.2.

22. TÓTH, A.; NÉMETH, E. AND HANGOS, K. M. (2010), 'Coloured Petri Net Diagnosers for Lumped Process Systems', KES'2010, 14th International Conference on Knowledge-Based and intelligent information & Engineering Systems, 8 -- 10 September 2010 Cardiff, Wales, UK', *LNAI 6277*, II, 389—398.

PhD Thesis

23. CSERCSIK, D. (2010), Dynamical modelling and model analysis in neuroendocrinology. PhD Dissertation, Péter Pázmány Catholic University, Faculty of Information Technology, Budapest, Hungary, (supervisor: G. Szederkényi and K.M. Hangos)..

BSc Diploma work

24. SONNEVEND, I. (2010) Analysis and model based control of a quadrotor helicopter. BSc Diploma work, Péter Pázmány Catholic University, Faculty of Information Technology, Budapest, Hungary (supervisor: G. Szederkényi)

MSc Diploma work

25. RUDAN, J. (2010) Developing an autonomous wheelchair using modern mobile robotic algorithms. MSc Diploma work, Péter Pázmány Catholic University, Faculty of Information Technology, Budapest, Hungary (supervisor: G. Szederkényi)
26. TUZA, Z. (2010) Analysis and development of localization and map building algorithms in mobile robotics. MSc Diploma work, Péter Pázmány Catholic University, Faculty of Information Technology, Budapest, Hungary (supervisor: G. Szederkényi)
27. JÓZSA, G. (2010) S-57 integration and propulsion modeling for autonomous underwater vehicles. MSc Diploma work, Péter Pázmány Catholic University, Faculty of Information Technology, Budapest, Hungary (supervisor: G. Szederkényi)

RESEARCH GRANTS

Project title: **Control and Diagnosis of Nonlinear Systems based on First Engineering Principles**
Hungarian National Science Foundation (OTKA)
Supervisor: **K. Hangos**
OTKA grant No.: K67625
Duration: 2007–2011

Project title: **A Multiscale - Multifunctional Approach to Advanced Diagnosis and Operator Performance in Complex Process Systems**
Australian Research Council (ARC)
Principal investigator: **K. Hangos**
ARC grant No.: LP0776636
Duration: 2008–2011

EDUCATIONAL ACTIVITY

Graduate courses held:

Péter Pázmány Catholic University, Budapest

G. Szederkényi: Lecture on Computer Controlled Systems
Faculty of Information Technology,
2 hours/week, 2nd semester of 2009/2010

D. Csercsik: Computer Controlled Systems (Tutorial)
Faculty of Information Technology,
2 hours/week, 2nd semester of 2009/2010

G. Szederkényi: Lecture on Robot Manipulators (with Gy. Cserey)
Faculty of Information Technology,
10 hours, 2nd semester of 2009/2010

University of Pannonia

K. M. Hangos: Lecture on Diagnosis methods based on discrete models
Department of Electrical Engineering and Information Systems,
4 hours/week, 1st semester of 2010/2011

PH.D. STUDENTS

Under the supervision of K. M. Hangos:

Sz. Rozgonyi: Modelling and control of hybrid (switching) process systems

University of Pannonia, Veszprém, Department of Electrical Engineering and Information Systems, PhD school on "Informatics"
(2004-2007)

A. Tóth: Intelligent diagnosis of complex process systems
University of Pannonia, Veszprém, Department of Electrical Engineering and Information Systems, PhD school on "Informatics"
(2008-2011)

G. Balló: State and process tomography of quantum systems
University of Pannonia, Veszprém, Department of Electrical Engineering and Information Systems, PhD school on "Informatics"
(2008-2011)

Under the supervision of G. Szederkényi:

D. Csercsik: Computer-Aided Investigation of Nonlinear Physiological Systems
Péter Pázmány Catholic University, Faculty of Information Technology, Interdisciplinary PhD School
(2006-2008)

Z. Tuza: High level semantic map construction for autonomous navigation.
Péter Pázmány Catholic University, Faculty of Information Technology, Interdisciplinary PhD School
(2010-2013)

J. Rudan: Intelligent, biologically motivated methods for autonomous navigation.
Péter Pázmány Catholic University, Faculty of Information Technology, Interdisciplinary PhD School
(2010-2013)