Research teams

Research team in the field of modern control techniques and industrial informatics

Center of Modern Control Techniques and Industrial Informatics (OAI)

Vysokoškolská 4

042 00 Košice

Slovensko

http://kyb.fei.tuke.sk,
http://web.tuke.sk/kkui/

Member‘s list of the research team

- doc. Ing. Ján Jadlovský, CSc.
- doc. Ing. Anna Jadlovská, PhD.
- Ing. Slávka Jadlovská, PhD.
- Ing. Matej Oravec
- Ing. Ján Čabala
- Ing. Dominik Vošček
- Ing. Lukáš Koska
- Ing. Jaroslav Socháň

Research focus

Research activities are primarily focused on:

- research of methods and development of tools for **hybrid modeling and control of cyber-physical systems** in order to implement the obtained results at all levels of distributed control systems in accordance with the Smart Industry - Industry 4.0 concept and the Internet of Things
- research and development of new methods and algorithms for the modeling, identification, control and diagnostics of **underactuated/ fully actuated nonlinear dynamic systems** in order to experimentally verify the proposed methodology using modern simulation tools
- research and development in the field of application utilization of methods for modeling, control and virtualization of **mobile robots** using classic approaches and methods of artificial intelligence, design and implementation of mobile robot with

implementation of sensors and actuators and their application in special conditions, development focused on the design and implementation of special **mobile robotic workplaces**

- development and research in the field of **flexible production systems**, automated and robotized production lines with a focus on design (algorithmization), implementation (development of mechanical, pneumatic, electrical and program part), modeling, simulation, control, diagnostics and optimization of production lines on all control levels and during all stages of implementation.
- **design of diagnostic systems** for the diagnosis of vibrations for cybernetic systems (vibro-diagnostics) with the application of accelerometers, strain gauges, etc., diagnostics for the measurement and evaluation of noise of mechanical devices and diagnostics aimed at measuring and using means of industrial thermovision.

Importance of research

The focus of the research team is in line with current trends not only in ICT but overall in economic and social life. The main benefit of CMCTaII's research activities is the development and application of methodology in the design and implementation of distributed control systems of production systems during all phases of the implementation (design, analysis, simulation, program and technical implementation, implementation, verification and validation of systems) application of modern control methods and artificial intelligence with the use of Internet technology, extensive database systems, industrial and mobile robotics, This integration presupposes the knowledge of a wide range of hardware tools (sensors, actuators, controllers (PLCs), computer servers of various complexities), software (simulation, technological process control, database information systems), communication standards for different protocols and interfaces. The research and development is supported by a set of simulation and physical laboratory models that have been developed in the framework of the research tasks and in cooperation with the practice and are integrated within the 5-level pyramidal model. The pyramid architecture is updated according to the application of state-of-the-art technology.

Solving of current problems

The research team is involved in the solution:

- tasks focused on the application of modern methods suitable for modeling and control of hybrid cyber-physical models using classical approaches and UI methods to simulate the proposed methodology and to verify and implement it to the network structure of distributed control system at KKUI
- tasks within international project of basic research (**Experiment ALICE on LHC at CERN**) focused on **Study of strongly interacting substances at extreme conditions** in Pb-Pb precipitation with energy 5.02 TeV on a pair of nucleons and precipitations p-p with energy 13 TeV in the ALICE experiment on the LHC accelerator at CERN. The research intention of the TU Košice group is focused on ITS innovation, with an emphasis on the development of a Pixel Detector with the requirement to identify the paths of Pb-Pb precipitations at 14 TeV per n-n pair. **Research is focused on three areas**: Pixel Detector Control, Development of Hybrid Integrated Circuit HIC (Hybrid Integrated Circuit) for collecting and processing signals from ALICE detectors, and development of program modules for the DCS Communication Infrastructure.
- tasks to implement a **digital enterprise project** in line with the Smart Industry 4.0 concept. The output is a 5-level pyramid architecture that enables the transfer of

knowledge technology into applied practice with emphasis on methods of non-destructive diagnostics.

Solved projects

International project of basic research and development ALICE CERN:

2016-2020: **ALICE KE FEI TUKE –** Experiment ALICE on LHC at CERN: Study of strongly interacting substances at extreme conditions (http://alice-cern.fei.tuke.sk/), doc. Ing. J. Jadlovský, CSc., TUKE responsible researcher

Outputs within ALICE Collaboration include 51 CC publications (http://alice-cern.fei.tuke.sk/index.php/publikacie/#collaboration) and 3 publications which were presented by posters at international conference ICALEPCS 2017 with subsequent publication in the conference proceedings (http://alice-cern.fei.tuke.sk/index.php/2017/10/06/konferencia-icaleps-2017/)

Information System for ALICE Experiment Data Access. In: ICALEPCS 2017,16th International Conference on Accelerator and Large Experimental Physics Control Systems, Barcelona, Spain. 4 pages. ISBN 978-3-95450-193-9 Jadlovský, J. - Jadlovská, S. - Čabala, J. - Jadlovská, A. - Čerkala J. - Kopčík, M. - Oravec, M. - Vošček, D. - Tkáčik, M. - Hanc, E. - Chochula P. - Bond, P.M.

A Novel General Purpose Data Acquisition Board with a DIM Interface. In: ICALEPCS 2017,16th International Conference on Accelerator and Large Experimental Physics Control Systems, Barcelona, Spain. 4 pages. ISBN 978-3-95450-193-9 Jadlovský, J. - Jadlovská, A. - Jadlovská, S. - Oravec, M. - Vošček, D. - Kopčík, M. - Čabala, J. - Tkáčik, M. - Chochula, P. - Pinazza, O.

Communication Architecture of the Detector Control System for the Inner Tracking System. In: ICALEPCS 2017,16th International Conference on Accelerator and Large Experimental Physics Control Systems, Barcelona, Spain. 4 pages. ISBN 978-3-95450-193-9 Jadlovský, J. - Jadlovská, A. - Jadlovská, S. - Oravec, M. - Vošček, D. - Kopčík, M. - Čabala, J. - Tkáčik, M. - Chochula, P. - Pinazza, O.

National projects:

- 1/2017 – 12/2017: GRANT FEI-2016-33 **Research Laboratory of Nonlinear Underactuated Systems** (http://granty.fei.tuke.sk/home/granty-2015?func=viewGrant;sequenceNumber=33)

  Project website: (http://matlab.fei.tuke.sk/underactuated/)

  Jadlovská, S., Vošček, D.: Research Laboratory of Nonlinear Underactuated Systems, *Mechatronics 4.0 in Engineering Education* at DTU – International Seminar on Internet of Things, Digitalization, Industry 4.0, Cyber – Physical Systems and Mechatronics Education, DTU Copenhagen, 20.june – 21.june **2017 (active participation with the poster http://matlab.fei.tuke.sk/akreditacia/subory/kodan3.pdf)**

- 2011-2014: **VEGA** 1/0286/11 - Dynamic Hybrid Architectures of Multiagent Network Control Systems

- 2008-2010: **VEGA** 1/0617/08 - Multiagent Network Control Systems with Automatic Reconfiguration
- 2015-2017: **KEGA** 001TUKE-4/2015 - CyberLabTrainSystem - Demonstrator and Trainer of Information-Control Systems - innovation
- 2012-2014: **KEGA** 021TUKE – 4/2012 CyberLabTrainSystem - Demonstrator and Trainer of Information-Control Systems
- 2011-2013: **KEGA** 034TUKE - 4/2011 - Development of modern university textbooks for the core units of newly-transformed study program "Cybernetics and information-control systems" in second degree of study
- 2010-2011: **KEGA** 037 – 011TUKE/2010 - Cybernetic Educational Centre

Funded from the Structural Funds:

- **2015-2017: TECHNICOM** - University Science Park Technicom for innovative applications with knowledge technology support – 2nd. phase, ITMS code:313011D232, c*o-financed by the ERDF, Centrum for nondestructive diagnostic of technological processes with standard software package for control and communication (activity 3.1, PP 7)*
- **2013 - 2015: TECHNICOM** - University Science Park Technicom for innovative applications with knowledge technology support, ITMS code 26220220182, co-financed by the ERDF, *Centrum for nondestructive diagnostic of technological processes with standard software package for control and communication (activity 3.1, PP 7)*
- **2010 - 2013**: **CE-FEI-II** - Development of the Center of Information and Communication Technologies for Knowledge Systems (Project supported by the Agency of the Ministry of Education for the Structural Funds of EU ITMS 26220120030
- **2009 - 2011**: **CE-FEI-I** - Development of the Center of Information and Communication Technologies for Knowledge Systems (Project supported by the Agency of the Ministry of Education for the Structural Funds of EU ITMS 26220120020)

Collaboration with academic institutions and industry

- Institute of Robotics and Cybernetics, FEEI, STU in Bratislava
- Faculty of Applied Sciences, University of West Bohemia in Plzeň, Czech republic
- European Organization for Nuclear Research– CERN, Geneve, Switzerland
- Institute of Physics PF UPJŠ in Košice, Department of Nuclear Physics and Subnuclear Physics, Košice
- Institute of Experimental Physics SAS in Košice
- Methodological and Pedagogical Center, MPC Regional Office**,** Košice
- Methodological and Pedagogical Center, MPC Regional Office, Prešov .
- ZŤS VVU Košice
- Kybernetika, s.r.o., Košice
- SPINEA, s.r.o., Okrajová 33, Prešov
- OMNIA KLF, a.s. Kukučínová 2734, Kysucké Nové mesto
- Rockvell Automation Praha
- Oracle, Bratislava
- Humusoft , s.r.o., Praha, Czech Republic

Selected publications

AAB - Scientific monographs released in home publishers

AAB003 [27992] **Modelovanie a riadenie dynamických procesov s využitím neurónových sietí** / Anna Jadlovská - Košice : Informatech - 2003. - 173 s. - ISBN 80-88941-22-9, [JADLOVSKÁ, Anna]

AAB001 [127757] **Automatizácia v metóde Photostress** / František Trebuňa ... [et al.] - 1. vyd. - Košice : TU - 2012. - 285 s.. - ISBN 978-80-553-1207-1.
[TREBUŇA, František - JADLOVSKÝ, Ján - FRANKOVSKÝ, Peter - PÁSTOR, Miroslav]

AAB006 [142586] **Návrh algoritmov prediktívneho riadenia s využitím nelineárnych modelov fyzikálnych systémov** / Štefan Jajčišin, Anna Jadlovská - 1. vyd - Košice : elfa - 2013. - 139 s.. - ISBN 978-80-8086-229-9., [JAJČIŠIN, Štefan - JADLOVSKÁ, Anna]

AAB001 [142603] **Moderné metódy modelovania a riadenia nelineárnych systémov** / Anna Jadlovská, Slávka Jadlovská - 1. vyd - Košice : elfa - 2013. - 257 s.. - ISBN 978-80-8086-228-2.
[JADLOVSKÁ, Anna - JADLOVSKÁ, Slávka]

ACB - University textbooks released in home publishers

ACB001 [143235] **Distribuované systémy riadenia** / Ján Jadlovský, Matej Čopík, Peter Papcun - 1. vyd - Košice : elfa - 2013. - 215 s.. - ISBN 978-80-8086-227-5.,[JADLOVSKÝ, Ján - ČOPÍK, Matej - PAPCUN, Peter]

ADC - Scientific work in currect content journals

ADC001 [22097] **Optimal control and approximation of variational inequalities** / Kamil Hrubina, Anna Jadlovská - 2002.In: The international journal of systems & cybernetics. Vol. 31, no. 9/10 (2002), p. 1401-1408. - ISSN 0368-492X Spôsob prístupu: *http://www.emeraldinsight.com/0368-492X.htm*., [HRUBINA, Kamil - JADLOVSKÁ, Anna]

ADC002 [110390] **Algorithms of Optimal Control Methods for Solving Game Theory problems** / Anna Jadlovská, Kamil Hrubina - 2011.In: Kybernetes. Vol. 40, no. 1-2 (2011), p. 290-299. - ISSN 0368-492X , [JADLOVSKÁ, Anna - HRUBINA, Kamil]

ADC - Scientific work in current content journals (ALICE COLLABORATION) are presented in http://alice-cern.fei.tuke.sk/index.php/publikacie/#collaboration

ADM - Scientific papers in foreign journals registered in the Web of Science or SCOPUS databases

ADM001 [134461] **A complex overview of modeling and control of the rotary single inverted pendulum system** / Slavka Jadlovska, Jan Sarnovsky - 2013.In: Advances in Electrical and Electronic Engineering. Vol. 11, no. 2 (2013), p. 73-85. - ISSN 1336-1376 Spôsob prístupu: *http://advances.utc.sk/index.php/AEEE/article/view/773*.,[JADLOVSKÁ, Slávka - SARNOVSKÝ, Ján]

ADN - Scientific papers in home journals registered in the Web of Science or SCOPUS databases

ADN001 [131454] **Modelling of Classical and Rotary Inverted Pendulum Systems - a Generalized Approach** / Slávka Jadlovská, Ján Sarnovský - 2013.In: Journal of Electrical Engineering. Roč. 64, č. 1 (2013), s. 12-19. - ISSN 1335-3632,Spôsob prístupu: *http://iris.elf.stuba.sk/JEEEC/data/pdf/1_113-2.pdf*., [JADLOVSKÁ, Slávka - SARNOVSKÝ, Ján]

ADN002 [179325] **Application of neural models as controllers in mobile robot velocity control loop** / Jakub Čerkala, Anna Jadlovská - 2017. In: Journal of Electrical Engineering. Roč. 68, č. 1 (2017), s. 39-46. - ISSN 1335-3632 [ČERKALA, Jakub - JADLOVSKÁ, Anna]

ADE - Scientific work in foreign non-current content journals

ADE007 [117023] **Application of results of experimental identification in control of laboratory helicopter model** / Kamil Dolinský, Anna Jadlovská - 2011.In: Advances in Electrical and Electronic Engineering. Vol. 9, no. 4 (2011), p. 157-166. - ISSN 1804-3119
Spôsob prístupu: *http://advances.utc.sk/index.php/AEEE/issue/view/31*., [DOLINSKÝ, Kamil - JADLOVSKÁ, Anna], SCOPUS

ADE009 [125149] **Predictive control algorithms verification on the laboratory helicopter model** / Anna Jadlovská, Štefan Jajčišin - 2012.In: Acta Polytechnica Hungarica. Vol. 9, no. 4 (2012), p. 221-245. - ISSN 1785-8860 Spôsob prístupu: *http://www.uni-obuda.hu/journal/Jadlovska_Jajcisin_36.pdf*. [JADLOVSKÁ, Anna - JAJČIŠIN, Štefan], THOMSON

ADE011 [148431] **Methodology for Experimental Identification of the Laboratory Hydraulic System** / Jakub Čerkala, Anna Jadlovská - 2014.In: Annals of Faculty Engineering Hunedoara - International Journal of Engineering. Vol. 12, no. 3 (2014), p. 33-40. - ISSN 1584-2665 Spôsob prístupu: *http://annals.fih.upt.ro/*., [ČERKALA, Jakub - JADLOVSKÁ, Anna]

ADE [185065] **MATLAB-based Tools for Modelling and Control of Underactuated Mechanical Systems** / Slávka Jadlovská, Lukáš Koska, Matej Kentos - 2017. In: Transactions on Electrical Engineering. Vol. 6, no. 3 (2017), p. 56-61. - ISSN 1805-3386 Spôsob prístupu: www.transoneleng.org... [JADLOVSKÁ, Slávka - KOSKA, Lukáš - KENTOS, Matej]

ADE [81639] **Predictive control design based on neural model of a non-linear system** / Anna Jadlovská, Nikola Kabakov, Ján Sarnovský - 2008. In: Acta Polytechnica Hungarica. Vol. 5, no. 4 (2008), p. 93-108. - ISSN 1785-8860 Spôsob prístupu: http://www.bmf.hu/journal... [JADLOVSKÁ, Anna - KABAKOV, Nikola - SARNOVSKÝ, Ján], THOMSON

ADE [117130] **Riadenie laboratórneho modelu hydraulického systému** / Š. Jajčišin, A. Jadlovská - 2011. In: ElectroScope. Vol. 2011, no. 3 (2011), 13 p.. - ISSN 1802-4564 Spôsob prístupu: **http://147.228.94.30/images/PDF/Rocnik2011/Cislo3_2011/r5c4c2.pdf...**
[JAJČIŠIN, Štefan - JADLOVSKÁ, Anna]

ADE [131322] **Application Results Identification Based on Genetic Algorithm in Nonlinear**

Control Design of Magnetic Levitation System / Peter Šuster, Anna Jadlovská - 2013. In: ElectroScope. Vol. 2013, no. 1 (2013), p. 1-10. - ISSN 1802-4564
Spôsob prístupu: **http://147.228.94.30/...** [ŠUSTER, Peter - JADLOVSKÁ, Anna]

AFC - Published papers at foreign scientific conferences

AFC [147037] **External Access to ALICE Controls Conditions Data** / Ján Jadlovský ... [et al.] - 2014. In: Journal of Physics : Conference Series (JPCS) : 20th International Conference on Computing in High Energy and Nuclear Physics : CHEP 2013 : Amsterdam, Netherlands. - Bristol : Institute of Physics Publishing, 2013 Vol. 513 (2014), p. 1-5. - ISSN 1742-6588 Spôsob prístupu: http://iopscience.iop.org/1742-6596/513/1/012015/pdf/1742-6596_513_1_012015.pdf...
[JADLOVSKÝ, Ján - JADLOVSKÁ, Anna - SARNOVSKÝ, Ján - JAJČIŠIN, Štefan - ČOPÍK, Matej - JADLOVSKÁ, Slávka - PAPCUN, Peter - BIELEK, Radoslav - ČERKALA, Jakub - KOPČÍK, Michal - CHOCHULA, Peter - AUGUSTINUS, Andre]

AFC [126896] **Using neural networks for physical systems behaviour prediction** / A. Jadlovská, Š. Jajčišin - 2012. In: AEI´2012 : International Conference on Applied Electrical Engineering and Informatics 2012 : August 26-September 02, 2012, Germany. - Košice : FEI TU, 2012 P. 36-41. - ISBN 978-80-553-1030-5 [JADLOVSKÁ, Anna - JAJČIŠIN, Štefan]

ADM003 [148893] **Mathematical Model of Robot Melfa RV-2SDB** / Peter Papcun, Ján Jadlovský - 2015.In: Advances in Intelligent Systems and Computing. - Switzerland : Springer, 2015 Vol. 316 (2015), p. 145-154. - ISSN 2194-5357, [PAPCUN, Peter - JADLOVSKÝ, Ján]

ADM003 [163187] **Advanced Generalized Modelling of Classical Inverted Pendulum Systems** / Slávka Jadlovská ... [et al.] - 2015.In: Advances in Intelligent Systems and Computing. - Switzerland : Springer, 2015 Vol. 316, no. 1(2015), p. 255-264. - ISSN 2194-5357, [JADLOVSKÁ, Slávka - SARNOVSKÝ, Ján - VOJTEK, Jaroslav - VOŠČEK, Dominik]

AFC [179180] **Cyber-physical system implementation into the distributed control system** / Anna Jadlovská, Slávka Jadlovská, Dominik Vošček - 2016. In: ScienceDirect : IFAC-PapersOnLine. - Amsterdam : Elsevier, 2016 Vol. 49, no. 25 (2016), p. 031-036. - ISSN 2405-8963
Spôsob prístupu: http://www.sciencedirect.com/science/article/pii/S2405896316326428...
[JADLOVSKÁ, Anna - JADLOVSKÁ, Slávka - VOŠČEK, Dominik]

ADF - Scientific work in home non-current content journals

ADF [25151] **Non-linear control using parameter estimation from forward neural model** / Anna Jadlovská - 2002. In: Journal of Electrical Engineering. Roč. 53, č. 11-12 (2002), s. 324-327. - ISSN 1335-3632 [JADLOVSKÁ, Anna]

ADF [28113] **State estimation and control of nonlinear process using neural networks** / Anna Jadlovská - 2003. In: Journal of Electrical Engineering. Roč. 54, č. 7-8 (2003), s. 213-217. - ISSN 1335-3632 [JADLOVSKÁ, Anna]

ADF [38564] **Using forward and inverse neural models for solving optimal tracking problem of non-linear system** / Anna Jadlovská - 2004. In: Journal of Electrical Engineering. Roč. 55, č. 5-6 (2004), s. 150-155. - ISSN 1335-3632 [JADLOVSKÁ, Anna]

ADF [108569] **Tracking trajectory of the mobile robot Khepera II using approaches of artificial intelligence** / Peter Šuster, Anna Jadlovská - 2011. In: Acta Electrotechnica et Informatica. Roč. 11, č. 1 (2011), s. 38-43. - ISSN 1335-8243

Spôsob prístupu: http://versita.metapress.com/content/w49u345370550552/fulltext.pdf...[ŠUSTER, Peter - JADLOVSKÁ, Anna]

ADF [108985] **Generalized Predictive Control Design for a Nonlinear Hydraulic System** / Anna Jadlovská, Štefan Jajčišin - 2011. In: Acta Electrotechnica et Informatica. Roč. 11, č. 2 (2011), s. 26-32. - ISSN 1335-8243
Spôsob prístupu: http://versita.metapress.com/content/252866x6185tp415/fulltext.pdf...

ADF016 [167694] **Nonholonomic Mobile Robot with Differential Chassis Mathematical Modelling and Implementation in Simulink with Friction in Dynamics** / Jakub Čerkala, Anna Jadlovská - 2015.In: Acta Electrotechnica et Informatica. Roč. 15, č. 3 (2015), s. 3-8. - ISSN 1335-8243 [ČERKALA, Jakub - JADLOVSKÁ, Anna]

ADF017 [181798] **Intelligent positioning plate predictive control and concept of diagnosis system design** / Matej Oravec, Anna Jadlovská - 2017. In: Journal of Manufacturing and Industrial Engineering (MIE). Roč. 15, č. 1-2 (2017), s. 1-9. - ISSN 1339-2972 Spôsob prístupu: http://www.qip-journal.eu/index.php/MIE/article/view/895... [ORAVEC, Matej - JADLOVSKÁ, Anna]

ADF018 [181824]**Sensors fault diagnosis algorithm design of a hydraulic system** / Matej Oravec, Anna Jadlovská - 2017. In: Acta Electrotechnica et Informatica. Roč. 17, č. 2 (2017), s. 30-37. - ISSN 1335-8243 [ORAVEC, Matej - JADLOVSKÁ, Anna]

ADF019 [185966] **Modelovanie, diagnostika a optimalizácia výrobných liniek** / Ján Jadlovský ... [et al.] - 2017. In: Strojárstvo. Roč. 21, č. 11 (2017), s. 104-106. - ISSN 1335-2938 Spôsob prístupu: http://www.engineering.sk/clanky2/stroje-a-technologie/3806-modelovanie-diagnostika-a-optimalizacia-... [JADLOVSKÝ, Ján - JADLOVSKÁ, Anna - JADLOVSKÁ, Slávka - ČERKALA, Jakub - KOPČÍK, Michal - ČABALA, Ján - ORAVEC, Matej - VARGA, Michal - VOŠČEK, Dominik]

ADF020 [186002] **Návrh metodiky pre modelovanie, riadenie, simuláciu a nedeštruktívnu diagnostiku mobilných robotov** / Anna Jadlovská ... [et al.] - 2017. In: Strojárstvo / Strojírenství. (2017), s. 1-10. - ISSN 1335-2938 Spôsob prístupu: http://www.engineering.sk/clanky2/automatizacia-robotizacia/3805-navrh-metodiky-pre-modelovanie-riad... [JADLOVSKÁ, Anna - JADLOVSKÝ, Ján - JADLOVSKÁ, Slávka - ČERKALA, Jakub - KOPČÍK, Michal - ČABALA, Ján - ORAVEC, Matej - VARGA, Michal - VOŠČEK, Dominik - TKÁČIK, Milan - BŘEZINA, Adam]

ADF021 [181825] **Solving optimal assembly line configuration task by multi-objective decision making methods** / Ján Čabala, Ján Jadlovský - 2017. In: Acta Electrotechnica et Informatica. Roč. 17, č. 2 (2017), s. 53-60. - ISSN 1335-8243 [ČABALA, Ján - JADLOVSKÝ, Ján]

ADF022 [185190] **Embedded Control System for Mobile Robots with Differential Drive** / Michal Kopčík, Ján Jadlovský - 2017. In: Acta Electrotechnica et Informatica. Roč. 17, č. 3 (2017), s. 42-47. - ISSN 1335-8243 Spôsob prístupu: http://www.aei.tuke.sk/papers/2017/3/08_Kopcik.pdf...
[KOPČÍK, Michal - JADLOVSKÝ, Ján]

AEC - Scientific work in foreign scientific journals, monographs

AEC015 [157366] **Dynamics with Friction in Mobile Robot Simulink Model** / Jakub Čerkala, Anna Jadlovská - 2015.In: Technical Computing Bratislava 2014 Proceedings. - Saarbrücken : Lap Lambert Academic Publishing, 2015 P. 65-81. - ISBN 978-3-659-40792-5
[ČERKALA, Jakub - JADLOVSKÁ, Anna]

AEC001 [157367] **Simulation of Particle Interaction in Two-Dimensional Model System Using MATLAB** / Anna Jadlovská ... [et al.] - 2015.In: Technical Computing Bratislava 2014 Proceedings. - Saarbrücken : Lab Lambert Academic Publishing, 2015 P. 141-156. - ISBN 978-3-659-40792-5
[JADLOVSKÁ, Anna - JADLOVSKÁ, Slávka - RABATIN, Peter - ŠVIKOVÁ, Mária]

AEC001 [157368] **Optimization Toolbox Usage in Solving Vector Optimization Tasks** / J. Čabala, J. Jadlovský - 2015.In: Technical Computing Bratislava 2014 Proceedings. - Saarbrücken : Lap Lambert Academic Publishing, 2015 P. 45-64. - ISBN 978-3-659-40792-5
[ČABALA, Ján - JADLOVSKÝ, Ján]

AEC001 [147037] **External Access to ALICE Controls Conditions Data** / Ján Jadlovský ... [et al.] - 2014.In: Journal of Physics : Conference Series (JPCS). Vol. 513 (2014), p. 1-5. - ISSN 1742-6588, Spôsobprístupu:*http://iopscience.iop.org/1742-6596/513/1/012015/pdf/1742-6596_513_1_012015.pdf*.
[JADLOVSKÝ, Ján - JADLOVSKÁ, Anna - SARNOVSKÝ, Ján - JAJČIŠIN, Štefan - ČOPÍK, Matej - JADLOVSKÁ, Slávka - PAPCUN, Peter - BIELEK, Radoslav - ČERKALA, Jakub - KOPČÍK, Michal - CHOCHULA, Peter - AUGUSTINUS, Andre]

AEC002 [148888] **Basic Motion Control of Differential-Wheeled Mobile Robot ALFRED** / Ján Jadlovský, Michal Kopčík - 2015.In: Advances in Intelligent Systems and Computing. - Switzerland : Springer, 2014 Vol. 316 (2015), p. 73-80. - ISSN 2194-5357, [JADLOVSKÝ, Ján - KOPČÍK, Michal]

AFD - Published papers at domestic scientific conferences

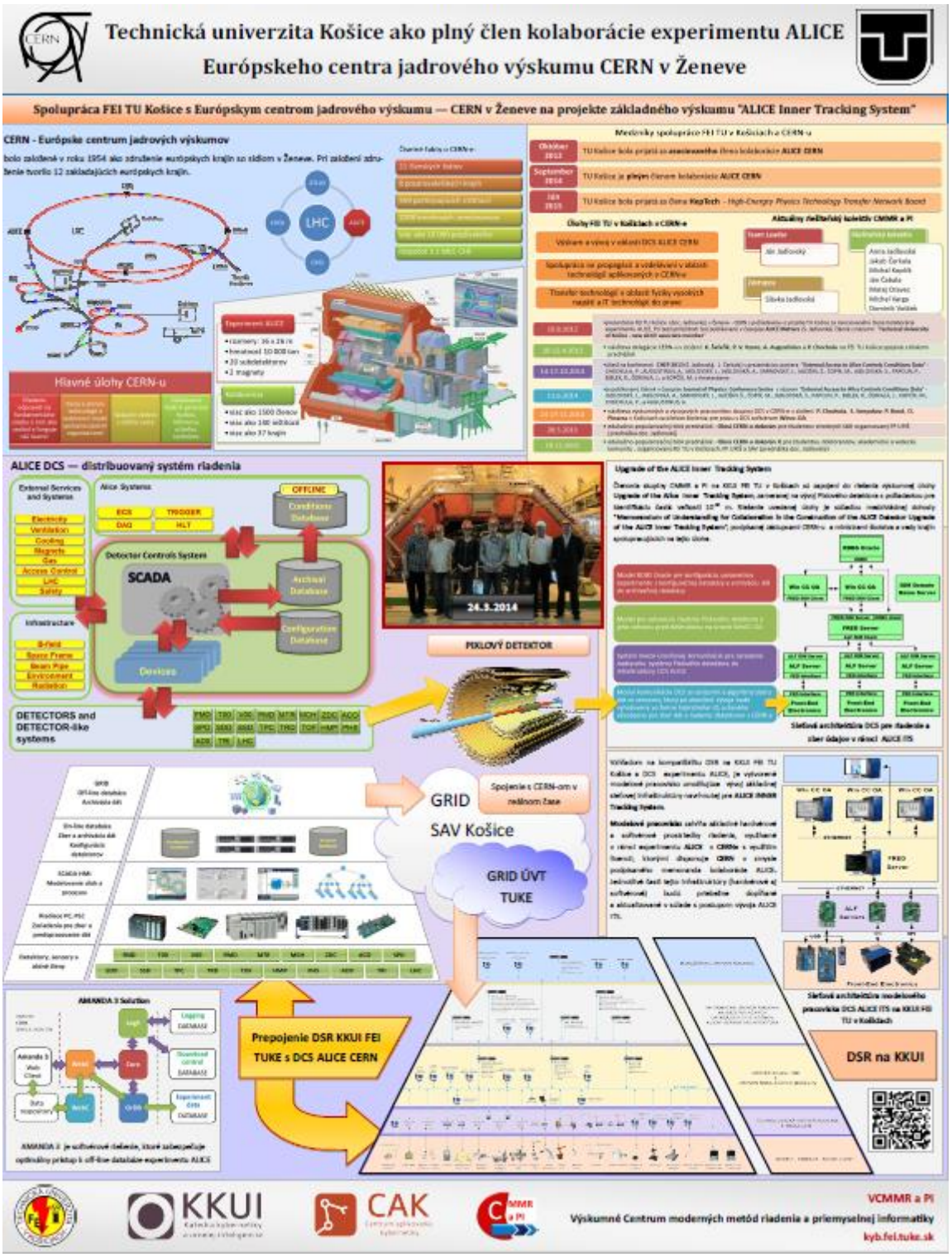
AFD [179179] **Modelling and control of a cyber-physical system represented by hydraulic coupled tanks** / Dominik Vošček, Anna Jadlovská - 2017. In: SAMI 2017. - Danvers : IEEE, 2017 S. 439-444. - ISBN 978-1-5090-5654-5
[VOŠČEK, Dominik - JADLOVSKÁ, Anna]

AFD [167726] **Research Activities of the Center of Modern Control Techniques and Industrial Informatics** / Ján Jadlovský ... [et al.] - 2016. In: SAMI 2016. - Danvers : IEEE, 2016 S. 279-285. - ISBN 978-1-4673-8739-2
[JADLOVSKÝ, Ján - JADLOVSKÁ, Anna - JADLOVSKÁ, Slávka - ČERKALA, Jakub - KOPČÍK, Michal - ČABALA, Ján - ORAVEC, Matej - VARGA, Michal - VOŠČEK, Dominik]

AFD [155569] **Model Predictive Control of Ball and Plate Laboratory Model** / Matej Oravec, Anna Jadlovská - 2015. In: SAMI 2015. - Danvers : IEEE, 2015 S. 165-170. - ISBN 978-1-4799-8220-2
[ORAVEC, Matej - JADLOVSKÁ, Anna]

AFD [118166] **Modeling and control design of magnetic levitation system** / P. Šuster, A. Jadlovská - 2012. - 1 elektronický optický disk (CD-ROM). In: SAMI 2012 : 10th IEEE Jubilee International Symposium on Applied Machine Intelligence and Informatics : proceedings : Herľany, Slovakia, January 26-28, 2012. - Budapest : IEEE, 2012 S. 295-299. - ISBN 978-1-4577-0195-5 Spôsob prístupu: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6208976...
[ŠUSTER, Peter - JADLOVSKÁ, Anna]

ALICE KE FEI TUKE – experiment ALICE on LHC at CERN: study of strongly interacting substances at extreme conditions (http://kyb.fei.tuke.sk/laboratoria/cern/files/Cern-Fei.pdf)



Project TECHNICOM - Centrum for nondestructive diagnostic
(http://matlab.fei.tuke.sk/akreditacia/subory/VCMMRaPI2016sami_poster.pdf)

SAMI 2016 - IEEE 14th International Symposium on Applied Machine Intelligence

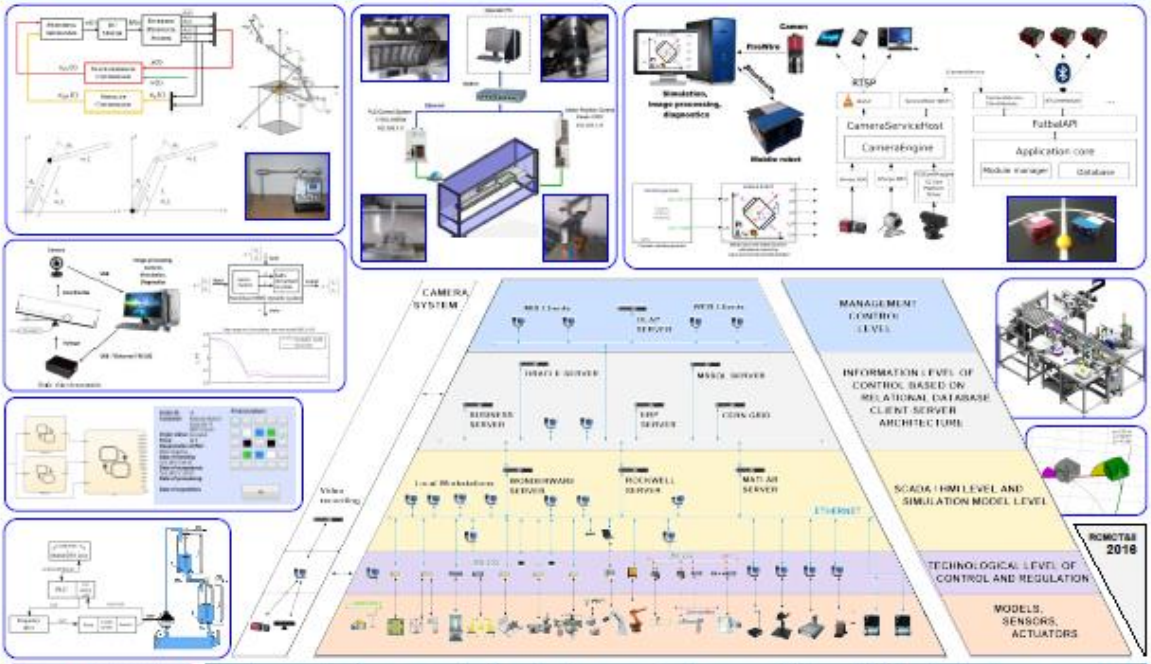
Research Activities of the Center of Modern Control Techniques and Industrial Informatics

J. Jadlovský*, A. Jadlovská, S. Jadlovská, J. Čerkala, M. Kopčík, J. Čabala, M. Oravec, M. Varga, D. Voščeк

Technical University of Košice,
Faculty of Electrical Engineering and Informatics,
Department of Cybernetics and Artificial Intelligence, Košice, Slovakia
*jan.jadlovsky@tuke.sk

Abstract – One of the research activities of the Center of Modern Control Techniques and Industrial Informatics (CMCT&II) is the *Center for Nondestructive Diagnostics of Technological Processes* (CNDTP) implemented as part of the TECHNICOM project at the Technical University of Košice in accordance with the project's intention to improve conditions for transferring research results into practice. The focus of the Center's research is on nondestructive, contactless diagnostics of technological processes relying on image recognition systems where images are scanned by means of contact-free characteristics scanning through grayscale, color or thermovision cameras. This equipment is integrated into the control systems of technological processes and interconnected with the mechatronic parts of technological devices or production lines such as servo systems, mobile and manipulator robots. Our project therefore involves a wide range of technical, programming and networking resources which allow the development, experimental verification and adjustment of solutions related to monitoring, diagnostics and control of technological processes.

Keywords— camera systems, mechatronic systems, production lines, diagnostic systems



Hardware and software aspects of applications covering the areas of interest of the Center (**camera systems**, **mechatronic systems**, **flexible manufacturing systems**, **diagnostic systems**) are implemented as independent modules and Included in the control and information system of a technological process using standard interfaces. All steps of the control system design process correspond to the specific level of the proprietary **five-level pyramid scheme** of a **distributed control system**, described in more detail at center's webpage: http://kyb.fei.tuke.sk/.

ACKNOWLEDGEMENTS: This work has been supported by the Research and Development Operational Program for project: University Science Park Technicom for innovative applications with knowledge technology support, ITMS code 26220220182, co-financed by the ERDF (80%) and by grant KEGA - 001TUKE-4/2015 (20%).

DCAI Department of Cybernetics and Artificial Intelligence
CAC Center for Applied Cybernetics
CMCT & II

Research laboratory for nonlinear underactuated systems
(http://matlab.fei.tuke.sk/akreditacia/subory/kodan3.pdf)

RESEARCH LABORATORY OF NONLINEAR UNDERACTUATED SYSTEMS

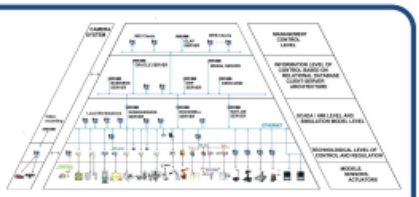
Slávka Jadlovská, PhD. – Assistant Professor
Dominik Vošček – PhD student
Department of Cybernetics and Artificial Intelligence
Faculty of Electrical Engineering and Informatics, Technical University of Košice, Slovakia
Email: slavka.jadlovska@tuke.sk, dominik.voscek@tuke.sk

OBJECTIVES

Underactuated systems, defined as mechanical systems with fewer control inputs than degrees of freedom, appear in a broad range of applications including aerospace, marine and locomotive systems. The motivation behind the research into underactuation is the ability to control nonlinear systems without complete control authority by exploiting their natural dynamics. This is similar to how biological systems execute motions involving a loss of instantaneous control authority. Underactuated devices are therefore expected to be more efficient, simpler and more reliable than their fully actuated alternatives. However, control of underactuated devices is more complex to design theoretically.
Our laboratory is the first research group to comprehensively deal with the topic of underactuated systems in Slovakia. Worldwide research groups which have inspired our research include:

The general objective of our research group is to identify and tackle the open research problems occurring at the mutual overlaps between three principal areas: **mathematical modeling** of underactuated mechanical systems, **optimal control** of nonlinear systems subject to constraints, and **hybrid systems theory**. We have often been employing the concept of cyber-physical systems.

Cyber-Physical Systems (CPS) integrate the dynamics of the physical processes with those of the software and networking, providing abstractions and modeling, design, and analysis techniques for the integrated whole. Physical subsystems in CPS operate in a time continuum, whereas cyber subsystems are composed of discrete, step-by-step operations. A key CPS challenge is to conjoin the engineering abstractions for continuous dynamics (such as differential equations) with computer science abstractions (such as algorithms).



In order to contribute to the modeling and control education at the DCAI-FEEI TU, our results are being integrated into the research and teaching activities of the *Center of Modern Control Techniques and Industrial Informatics* at the DCAI http://kyb.fei.tuke.sk. The results of hybrid modeling and control design for the considered cyber-physical systems are implemented at all levels of the **distributed control system infrastructure** in accordance with the **Industry 4.0** strategy.

TEAM & TEACHING

TEAMLEADER

Slávka JADLOVSKÁ, PhD.

- mathematical modeling, constrained optimal control, nonlinear control, hybrid systems, mechatronics and robotics
- underactuated systems (benchmarks, manipulators, hybrid control, robot locomotion – biped gait)
- 26 published scientific works in this area (10 in indexed journals/proceedings)
- 52 citations (20 in indexed journals)
- 2011-2017- supervisor/consultant to 18 bachelor and 14 diploma theses

PHD STUDENTS

Dominik Vošček – cyber-physical systems, hybrid systems, optimal control
Matej Oravec – diagnostics, distributed control systems, frequency analysis
Ján Čabala – optimization, information systems, assembly lines
Michal Kopčík – embedded systems, mobile robotics, diagnostics
Lukáš Kaska – hybrid systems, nonlinear control, legged robot locomotion
Samuel Tóth – robotics, information systems, signal processing

MASTER STUDENTS

Peter Gallik – physical modeling, intelligent control, multi-body systems
Patrik Andorko – optimal control, switched systems, web design

CURRENT COURSES (FIELD OF STUDY: CYBERNETICS)

Introduction to Control Engineering – linear system theory, elementary mathematical modeling, PID controller design, introduction to cyber-physical systems
Embedded Systems – development of applications based on microcontrollers, programming in machine-oriented languages, principles of Internet of Things
Simulation Systems – introduction to technical computing using MATLAB/Simulink (modeling and simulation of linear/nonlinear systems, feedback control)
Computer Systems in Control – development of PC applications with the focus on standard interfaces
Optimal Control of Hybrid Systems – nonlinear system theory, linearization, optimal control design, stability, elementary hybrid system theory
Control and Artificial Intelligence – advanced controller design (predictive/adaptive control), experimental identification, intelligent control
Distributed Control Systems – complex control in manufacturing organizations (PLC, SCADA, information systems), principles of Industry 4.0
Management Information Systems – multidimensional analysis of business data, introduction to big data processing

PAST COURSES

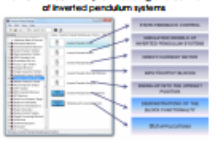
Computers and Algorithms – algorithm design and C programming, introduction to computing and hardware
Simulation Systems in Business Informatics – MATLAB programming with business applications (optimization)
Control of Technological Processes – principles of PLC control
Protocols and Interfaces – introduction to computer networks and the Internet
Introduction to Nonlinear Systems – nonlinear system theory (linearization, stability, nonlinear control design)
Models and Control of Industrial Processes – modeling of mechanical/mechatronic/electrical/hydraulic/pneumatic systems, experimental identification, control design

OUTLINE, CONTRIBUTION AND PERSPECTIVES

MATHEMATICAL MODELING OF UNDERACTUATED SYSTEMS USING LAGRANGIAN MECHANICS

Benchmark underactuated systems, such as inverted pendulum systems, two-link planar robots – Acrobot and Pendubot, the Inertia Wheel Pendulum or the convey-crane system create complex low-order nonlinear dynamics which enables us to gain insight into the principles of modeling and control of advanced, high-order underactuated systems. We have developed of a set of algorithms which determine the Lagrange equations of motion for a selected benchmark underactuated system. We specifically introduced the concept of a generalised [n-link] inverted pendulum system, which allows us to treat an arbitrary system of interconnected inverted pendula as a particular instance of the system of pendula attached to a given stabilising base, such as a cart (in 2D/3D) or a rotary arm.

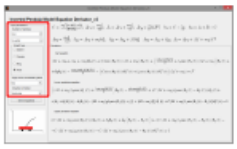
Inverted Pendula Modeling and Control (IPMoC) – Simulink block library for modeling and control of inverted pendulum systems



Our ultimate goal was to complete a readily available collection of mathematical and simulation models of underactuated mechanical systems serving as a testbed model basis in simulation experiments exploring their typical properties (such as analyses of open-loop dynamics and phase portraits) and testing linear and nonlinear control strategies.
The results obtained so far have provided a starting point for our current research of advanced underactuated systems, such as legged robots and the mechanism of robot walking, wheeled inverted pendulum systems or unmanned aerial vehicles.

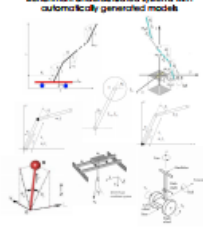
Application of Euler-Lagrange equations in modeling of a multi-body underactuated mechanical system

Automatic generation of motion equations for classical and rotary inverted pendulum systems with optional reference link position and attached weight

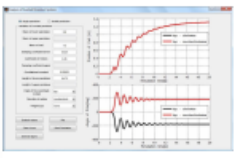


Automatic generation of motion equations for an Acrobot, Pendubot and Inertia Wheel Pendulum with optional reference link position

Benchmark underactuated systems with automatically generated models



Open-loop analysis of classical inverted pendulum systems with optional reference link position



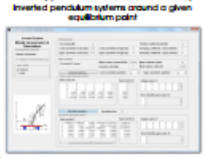
OPTIMAL CONTROL OF UNDERACTUATED SYSTEMS

Fully actuated systems possess a number of strong structural properties (feedback linearizability, passivity, linear parametrizability) which facilitate controller design. These are usually lost in underactuated systems. At the same time, undesirable properties (higher relative degree, nonminimum phase behavior) emerge.

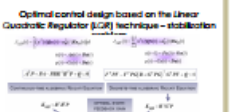
The goal of optimal control design for a linear, time-invariant system is to determine such feedback control so that a given optimality criterion is achieved. In case the considered linear system is actually a linear approximation of a nonlinear system around a given equilibrium, optimal techniques for linear systems yield an approximate, locally near-optimal stabilizing solution with guaranteed closed-loop stability and robustness.

State space representation and linear approximation of underactuated systems

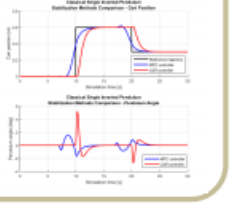
Linear approximation of classical and rotary inverted pendulum systems around a given equilibrium point



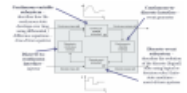
Optimal control design based on the Linear Quadratic Regulator (LQR) technique – stabilization



We have implemented and verified LQ control algorithms in a variety of control structures, and evaluated the need for nonlinear control techniques such as the state-feedback control design based on the state-dependent Riccati equation.
Model predictive control (MPC) is a discrete-time optimal control technique in which the control action for each time step is computed by solving an online optimization problem in finite time while considering input/state constraints. To solve problems arising from the structure of underactuated system, suitable adjustment of the MPC algorithm is required.

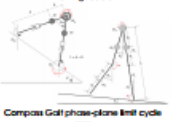


HYBRID SYSTEMS THEORY FOR MODELING AND CONTROL OF UNDERACTUATED SYSTEMS



Hybrid systems theory was developed to provide a convenient framework for modeling and control of systems characterized by an interaction between continuous (time-driven) and discrete (event-driven) dynamics. Hybrid models are useful if we have to consider an event-based description of the mechanical system dynamics, such as the configurations of legged walking robots. The Compass Gait is a principal example of an unpowered walking robot which performs gravity-induced passive motion on an inclined plane. This model can be gradually expanded to obtain a detailed walking robot model with natural dynamics.

Examples of benchmark passive walking robots



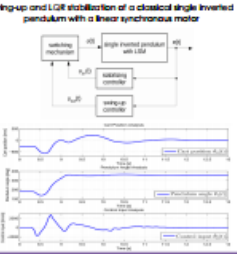
Compass Gait phase-plane limit cycle

Automatic generation of continuous and discrete dynamics (motion and transition equations) for passive bipeds with optional knees, torso and feet

We have explored control problems of underactuated systems which require us to employ switching control structures. A typical example constitutes the hybrid control setup of a swing-up and balancing controller for selected benchmark systems, where the swing-up is performed via energy-based methods or partial feedback linearization. Laboratory models of inverted pendulum systems have enabled us to verify the swing-up and stabilizing control algorithms while also considering the properties of the actuating mechanism.

Laboratory model of a) classical b) rotary inverted pendulum system

Swing-up and LQR stabilization of a classical single inverted pendulum with a linear synchronous motor



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