Zdeněk Hurák

Docent (associate professor, privatdozent) in control systems

March 30, 2023

Affiliations and positions

- 2004–present: Faculty of Electrical Engr., Czech Technical University in Prague, Czech Republic. Since 2009 **assistant professor**, establishing his *Advanced Algorithms for Control and Communications (AA4CC)* research group: `http://aa4cc.dce.fel.cvut.cz` within Dept. of Control Engineering. In 2016 promoted to the rank of **docent** ($\approx$ associate professor, privatdozent) after defending *habilitation*.

- 2000–2006: part-time researcher at Institute of Information Theory and Automation, Czech Academy of Sciences, Prague, Czech Republic.

- 1997–1999: teaching and lab assistant at Dept. of Aerospace Electrical Engr., Military Academy (now University of Defense) in Brno, Czech Republic.

Education

- 2000-2004: **Ph.D.** degree. Department of Control Engineering, Faculty of Electrical Engineering, Czech Technical University in Prague. Supervisor: Prof. Michael Šebek. Thesis title: ℓ_1-*optimal control - a polynomial approach*. Finding a numerically reliable solution for the problem of optimal control design minimizing the peak in the regulated signals when the exogenous signals are bounded and persistent. The solution relies upon truncations of large Toeplitz matrices and exhibits better conditioning then the available solution based on interpolations and Vandermonde matrices. The key result published in the prestigious *SIAM Journal on Control and Optimization*.

- 1992-1997: **Ing.** degree ($\approx$ M.Sc. or Dipl.Ing.), with honors. Dept. of Aerospace Electrical Engr., University of Defense (formerly Military Academy) in Brno, Czech Republic. Major specialization in avionics and weapon systems. Final project on reliability analysis of an ejection seat for L-39 aircraft. The compulsory military service within the first year of the preceding undergraduate program, then a noncommissioned officer. Served as a platoon leader and a deputy of a company leader. After graduation left the Czech Armed Forces with the rank of *sergeant* (OR-5).

Scholarships and visiting positions abroad

- Fulbright scholar at Dept. of Mech. Engineering and Center for Control, Dynamical Systems and Computation, College of Engineering, University of California, Santa Barbara, USA. Hosted by Prof. Bassam Bamieh. February through August 2014. Research in distributed control of distributed systems.

- Visiting researcher at Micro and Nano Scale Engineering group (MNSE), Dept. of Mech. Eng., TU Eindhoven, The Netherlands. Hosted by Prof. Yves Bellouard. May through December 2008. Setting up an experimental platform for dielectrophoresis-based micromanipulation.

- Boeing research fellow at International Institute of Theoretical and Applied Physics, Iowa State University, Ames, USA. March through June 1999. Research in integrated control and scheduling.

Membership and activities in professional societies and committees

- Senior Member of IEEE: Control Systems Society (member for 22 years, since 2000), Robotics and Automation Society, Intelligent Transportation Society; served as Chair of Control System Chapter of Czechoslovak Section of IEEE.

- Editorial boards: Kybernetika `http://www.kybernetika.cz` (2008-2014), Automa `http://www.automa.cz`.

- Member of IPC: IEEE Multi-Conference on Systems and Control, September 28-30, 2011, Denver, CO, USA; 7th International Workshop on Multidimensional (nD) Systems (nDS11), September 5-7, 2011, Poitiers, France; (Biennial) International Conference on Process Control (PC), Strbske Pleso, Slovakia, 2017, 2019, 2021, 2023.

- Member of the Jury for the Ministry of Education, Youth and Sports Prize for Excellent Educational Activities in Higher Education (2019–).

Research interests and background

- Optimal and robust control design techniques; optimization-based control design; control-related numerical and symbolic algorithms, in particular for polynomials and polynomial matrices.

- Distributed control of spatially distributed systems; networked-control; n-D systems; interconnected systems; applications to intelligent transportations, namely vehicular platoons, using vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication.

- Distributed micromanipulation by shaping force fields through actuator arrays (dielectrophoresis, magnetophoresis, . . .).

- High-accuracy motion control in robotics and mechatronics; inertial stabilization of aerial camera platforms.

Research projects/funding

- Advanced methods for on-board data processing in V2X systems. Doprava 2020+ program by the Technological Agency of Czech Republic. Bilateral R&D project with *Herman Elektronika* company. Duration: 2022–2024. The team budget: 7 mil. CZK.

- Intelligent public transportation using V2X (Vehicle-to-Everything) communication. EPSILON program by the Technological Agency of Czech Republic. Bilateral R&D project with *Herman Elektronika* company. Duration: 2018–2020. The team budget: 3.3 mil. CZK.

- Control Platform for High-Accuracy Electronics Assembly. TRIO program by the Ministry of Industry and Trade of Czech Republic. Bilateral R&D project with *EZConn Technologies CZ* company. Duration: 2017–2021. The team budget: 12.5 mil. CZK.

- Bio-inspired Assembly Process for Mesoscale Products and Systems. EC FP6 (STREP). Participation in a consortium lead by Dr. Yves Bellouard (TU Eindhoven, The Netherlands). Duration: 2006–2009. Managing 3 researchers (36 person-months). The team budget: 160 000 EUR.

- Center of Excellence for Advanced Bioanalytical Instrumentation. GAČR. Jointly with two other research labs (chemistry and biochemistry). Duration: 2012–2018. Managing research of 3 researchers, bringing in a foreign postdoctoral researcher. The team budget: 18.5 mil. CZK. Web: `http://www.biocentex.cz`.

(Other) industrial collaboration

- Design of several versions of a line-of-sight stabilization for an airborne camera system. Contractor/partner: Czech Air Force R&D Institute (VTÚL `http://vtul.cz`). Other partners: prof. Václav Hlaváč's Center for Machine Perception, ESSA Prague company. Responsible for the inertial stabilization subsystem; managing a small team of control engineers. 2006 through 2014.

- Courses on *automatic control* for industry: Honeywell Technology Solutions Lab, Brno, Czech Republic, 12 lectures, January 2008; STMicroelectronics Prague, Czech Republic, 6 lectures, January 2016.

- Robust control design for the Very Large Telescope (8.2m VLT). Contractor: European Southern Observatory, Santiago, Chile. Consulting for an ESO control engineer (Toomas Erm), using $\mathcal{H}_\infty$ norm minimization based loop-shaping for increasing the bandwidth of the altitude control system. January 2003 through December 2003.

- Reliability analysis of the PLAMEN fire control system for the L-159 light combat aircraft: FMEA, FMECA and FTA analyses, simulations, MIL-HDBK-217. Contractor: AEV, Ltd., Kromeriz, Czech Republic, January through March 1998.

Scientific end educational awards

- Ph.D. student Tomáš Michálek awarded the 2022 Werner von Siemens Prize for the Best Thesis on Industry 4.0 (awarded by Siemens Czech Republic).

- EEA Demonstrator Paper Prize at IFAC 2017 World Congress in Toulouse, France, for the paper "Time-Optimal Control for Bilinear Nonnegative-In-Control Systems: Application to Magnetic Manipulation" by Jiří Zemánek, Sergej Čelikovský a Zdeněk Hurák.

- 4th place at *2012 NIST Mobile Microrobotics Challenge* during IEEE ICRA, May 2012, St.Paul, MN, USA. Then 5th place at *2013 IEEE RAS Mobile Microrobotics Challenge* during IEEE ICRA, May 2013, Karlsruhe, Germany.

- Prize of the Rector of Czech Technical University for an outstanding research paper (Minimum distance to the range...) of the year 2006. Best paper (Robust stability of polynomials with complex coefficients) at an international student conference POSTER 2001, Prague, May 2001 (Czech Airlines prize).

Research publication activities

Author or coauthor of **56 publications** according to Web of Science (65 according to Scopus). The **H-index** is **11** according to Web of Science (**12** according to Scopus, and **15** according to Google Scholar). The total number of **citations** is **413** according to WoS (**544** according to Scopus, and **850** according to Google Scholar). ResearcherID: C-8373-2009. ORCID: 0000-0003-2923-4321.

SCI journal papers

- Gurtner, Martin, Jiří Zemánek, and Zdeněk Hurák. "Alternating direction method of multipliers-based distributed control for distributed manipulation by shaping physical force fields". *The International Journal of Robotics Research*, online first, February, 2023.

- Michálek, Tomáš, Aude Bolopion, Zdeněk Hurák, and Michaël Gauthier. "Electrorotation of Arbitrarily Shaped Micro-Objects: Modeling and Experiments". *IEEE/ASME Transactions on Mechatronics*, vol. 25, issue 2, 828–836, April 2020.

- Michálek, Tomáš, Aude Bolopion, Zdeněk Hurák, and Michaël Gauthier. "Control-Oriented Model of Dielectrophoresis and Electrorotation for Arbitrarily Shaped Objects", *Physical Review E*, vol. 99, no. 5, 053307, May, 2019.

- Zemánek, J., T. Michálek, a Z. Hurák, "Phase-shift feedback control for dielectrophoretic micromanipulation", *Lab on a Chip*, vol. 18, issue 12, pp. 1793–1801, June, 2018.

- Herman, I., D. Martinec, Z. Hurák, a M. Sebek, "Scaling in Bidirectional Platoons With Dynamic Controllers and Proportional Asymmetry", *IEEE Transactions on Automatic Control*, vol. 62, no. 4, pp. 2034—2040, April, 2017.

- Gurtner, M., K. Hengster-Movric, and Z. Hurák, "Green's function-based control-oriented modeling of electric field for dielectrophoresis", *Journal of Applied Physics*, 2, vol. 122, issue 5, pp. 054903, 08, 2017.

- Herman, I. and D. Martinec and Z. Hurak and M. Sebek, "Nonzero Bound on Fiedler Eigenvalue Causes Exponential Growth of H-Infinity Norm of Vehicular Platoon", *IEEE Transactions on Automatic Control*, vol. 60, no. 8, pp. 2248–2253, August 2015. DOI: 10.1109/TAC.2014.2366980

- Zemánek, J. and T. Michálek and Z. Hurák, "Feedback control for noise-aided parallel micromanipulation of several particles using dielectrophoresis", *Electrophoresis*, vol. 36, no. 13, pp. 1451–1458, 2015. DOI: 10.1002/elps.201400521.

- Martinec, D. and I. Herman and Z. Hurák and M. Šebek, "Wave-absorbing vehicular platoon controller," European Journal of Control, vol. 20, no. 5, pp. 237–248, Sep. 2014, doi: 10.1016/j.ejcon.2014.06.001.

- Hurák, Z. and F. Foret, "On benchmark problems, challenges, and competitions in electrokinetics— A review", *Electrophoresis*, vol. 36, no. 13, pp. 1429–1431, 2015. DOI: 10.1002/elps.201400520.

- Martinec, D. and I. Herman and Z. Hurák and M. Šebek, "Wave-absorbing vehicular platoon controller", *European Journal of Control*, vol. 20, no. 5, pp. 237–248, September 2014. DOI: 10.1016/j.ejcon.2014.06.001.

- Řezáč, M. and Hurák, Z. "Structured MIMO H-infinity design for dual-stage inertial stabilization: Case study for HIFOO and Hinfstruct solvers", *Mechatronics*, Vol. 23, issue 8, pp. 1084–1093, December 2013. DOI: 10.1016/j.mechatronics.2013.08.003.

- Augusta, P. and Hurák, Z. "Distributed stabilisation of spatially invariant systems: positive polynomial approach", *Multidimensional systems and signal processing*, vol. 24, issue 1, pp. 3–21, March 2013. DOI: 10.1007/s11045-011-0152-5.

- Hurák, Z. and Řezáč, M. "Image-based pointing and tracking for inertially stabilized airborne camera platform", *IEEE Transactions on Control Systems Technology*, vol. 2, issue 5, pp. 1146–1159 , September, 2012. DOI: 10.1109/TCST.2011.2164541.

- Špiller, M. and Hurák, Z. "Hybrid charge control for stick-slip piezoelectric actuators", *Mechatronics*, Elsevier, Vol. 21, No. 1, Pages 100–108, 2011. DOI: 10.1016/j.mechatronics.2010.09.002.

- Šprdlík, O., Hurák, Z., Hoskovcová, M., Ulmanová, O. and Růžička, E. "Tremor analysis by decomposition of acceleration into gravity and inertial acceleration using inertial measurement unit", *Biomedical Signal Processing and Control*, Elsevier, 2010. DOI: 10.1016/j.bspc.2010.09.004.

- Cichy, B., Augusta, P., Rogers, E., Galkowski, K., Hurák, Z. "On the control of distributed parameter systems using a multidimensional systems setting", *Mechanical Systems and Signal Processing*, vol.22, No. 7, pp. 1566–1581, 2008. DOI: 10.1016/j.ymssp.2008.01.012.

- Hurák, Z., Hromčík, M., Špiller, M. "Minimization of ℓ_2 norm of the error signal in posicast input command shaping: a polynomial approach", *International Journal of Robust and Nonlinear Control*, Wiley, Vol. 17, No. 8 , pp. 706–719, May 2007. DOI: 10.1002/rnc.1128.

- Hurák, Z., Böttcher, A., Šebek, M. "Minimum distance to the range of a banded lower triangular Toeplitz operator in ℓ_1 norm and application in ℓ_1 optimal control", *SIAM Journal on Control and Optimization*, Vol. 45, No. 1, pp. 107–122, 2006. DOI: 10.1137/S0363012903437940.

- Hurák, Z. Discussion on: "On frequency weighted balanced truncation: Hankel singular values and error bounds" by T. Van Gestel, B. de Moor, B.D.O.Anderson and P. Van Overschee. *European Journal of Control*, Vol. 7, Number 6, 2001. [Editorial type of publication].

Teaching experience

- Six Ph.D. candidates brought to a successful defense: Petr Augusta—2011, Otakar Šprdlík—2012, Martin Řezáč—2014, Ivo Herman—2017 (co-supervised with Michael Šebek), Jiří Zemánek—2018, Tomáš Michálek—2020. All the doctoral students have spent at least 4 months in a lab of some partners abroad (University of Twente, University of Southampton, Technical University in Eindhoven, FEMTO-ST Besancon). All finished defended with at least one paper in a good (SCI) journal. The reviewers of the candidates' final theses were well-recognized expert from top universities or research institutions abroad (Edinburgh, FEMTO-ST Besançon, UCSB, KTH, Max Planck Stuttgart, . . .). Currently advising Ph.D. students: Loi Do and Martin Gurtner.

- Supervised in total some 28 final graduate (Ing/MSc) and some 16 final undergraduate student projects.

- Created and taught a graduate course on *optimal and robust control*. The course taught in English. Inverted classroom teaching model used (lectures on Youtube channel). Attendance: around 30 students every year. Created and taught undergraduate course on *modeling and simulation of dynamic systems*. Around 50 students every year. Sponsorship from an industrial companies used to provide the students with cca 40 copies of a worldwide used textbook. Inverted classroom teaching model used (lectures on Youtube: AA4CC channel).

- Guarantor of *Cybernetics and robotics* graduate program at FEE CTU in Prague. Coordination of the design and the realization of the program.

(Some) media coverage

- Inverviews for major Czech magazines and radios about *flipped learning* method applied within my courses: "U nalejvárny být nemusím", Respekt, 44/2018: `https://www.respekt.cz/tydenik/2018/44/u-nalejvarny-nemusim-byt`; "Přednáška doma a domácí úkoly ve škole? Metoda převrácené výuky ukazuje, kudy může kráčet vysoké školství", Český rozhlas Radiožurnál, 28th October 2018, `https://radiozurnal.rozhlas.cz/prednaska-doma-a-domaci-ukoly-ve-skole-metoda-prevracene-vyuky-ukazuje-kudy-muze-7646382`.

- A 30-minute documentary about the AA4CC team (co-)developing an inertially stabilized aerial camera platform on the main Czech national TV channel, 2012: `https://www.ceskatelevize.cz/porady/10121359557-port/212563241900004/772-pripad-kamerove-hlavice/` .

- An article about the success of AA4CC team at 2012 NIST Mobile Microrobotics Challenge on the main Czech news website iDnes.cz: `http://technet.idnes.cz/roboti-bezpilotni-letadla-dcm-/tec_technika.aspx?c=A120822_145034_tec_technika_pka`.

- Youtube channel `http://www.youtube.com/user/aa4cc`.

Address, contact information

Zdeněk Hurák, Katedra řídicí techniky FEL ČVUT, Karlovo náměstí 13/E, 12135, Praha 2, Czech Republic. Tel: +420-224357683, Cell.: +420-608345922. Web: `http://aa4cc.dce.fel.cvut.cz`. E-mail: `hurak@fel.cvut.cz`.