Vetenskapsrådet

Application

2015-03-31

2015-04448	Johansson, Rolf	NT-14

Information about applicant

Name: Rolf Johansson

Doctorial degree: 1983-05-31

Birthdate: 19530817

Academic title: Professor

Gender: Male

Employer: Lunds universitet

Administrating organisation: Lunds universitet

Project site: Reglerteknik 107161

Information about application

Call name: Forskningsbidrag Stora utlysningen 2015 (Naturvetenskap och teknikvetenskap)

Type of grant: Projektbidrag

Focus: Fri

Subject area:

Project title (english): Active Control of Compressor Systems Based on New Methods of Nonlinear Dynamic Feedback Stabilization

Project start: 2016-01-01

Project end: 2018-12-31

Review panel applied for: NT-14, NT-1, NT-2

Classification code: 20399. Annan maskinteknik

Keywords: Moore-Greitzer model, Stabilization, Dynamic feedback, Nonlinear systems, State estimation

Funds applied for

Year:	2016	2017	2018
Amount:	1,381,000	1,407,000	1,433,000

Participants

Name: Leonid Freidovich

Doctorial degree: 1999-06-16

Birthdate: 19730704

Academic title: Docent

Gender: Male

Employer: Umeå universitet

Descriptive data

Project info

Project title (Swedish)*

Aktiv Reglering av Kompressorsystem Baserad på Nya Metoder för Icke-Lineär Dynamisk Återkopplingsstabilisering

Project title (English)*

Active Control of Compressor Systems Based on New Methods of Nonlinear Dynamic Feedback Stabilization

Abstract (English)*

This proposal deals with a number of facts related to the output feedback stabilization of the Moore-Greitzer compressor model. We show that quadratic feedback stabilization of the surge subsystem of the three-state Moore-Greitzer compressor model, which ensures an absence of additional equilibria in the augmented with stall dynamics closed loop system, implies convergence of all solutions to the unique equilibrium at the origin. Then some steps in developing such output feedback controller for surge subsystem are discussed, and a family of controllers is presented. Based on our new theoretical results on integrability, stability, nonlinear dynamic output feedback control, we wish to pursue active control application to compressor systems and experimental verification.

Popular scientific description (Swedish)*

Kompressorsystem är vanligt förekommande komponenter i energi- och strömningstekniska system såsom gasturbiner, jetmotorer, turboenheter i bilmotorer, kylskåp, etc., vars tryck- och flödesstabilitet kan förbättras med reglertekniska metoder. Icke-linjära system är en sammanfattande benämning på tekniska system, som är har olika karakteriska uppföranden beroende på driftförhållande. En vanlig teknisk erfarenhet är att sådan system är svåra att styra och att automatisera. Vår ansökan avser att utveckla två metoder, som kan väsentligt nedbringa behovet av den mätinformation, som behövs för informationsåterföring (feedback). En av metoderna, separationsprincipen med tidigare effektiv tillämpning för linjära system, har tidigare trots vara omöjlig att tillämpa annat än på obetydliga klasser av icke-linjära system, har enligt våra preliminära resultat visat sig tillämpbar på mycket större klasser av system med mycket intressant och betydelsefull teknisk tillämpning. En första tillämpning av våra resultat kommer att ske i våra experimentella projekt, varvid information kommer att delges våra industrikontakter.

Project period

Number of project years*

3

Calculated project time*

2016-01-01 - 2018-12-31

Classifications

Select a minimum of one and a maximum of three SCB-codes in order of priority.

Select the SCB-code in three levels and then click the lower plus-button to save your selection.

SCB-codes*

2. Teknik > 203. Maskinteknik > 20399. Annan maskinteknik

Enter a minimum of three, and up to five, short keywords that describe your project.

Keyword 1*

Moore-Greitzer model

Keyword 2*

Stabilization

Keyword 3*

Dynamic feedback

Keyword 4

Nonlinear systems

Keyword 5

State estimation

Research plan

Ethical considerations

Specify any ethical issues that the project (or equivalent) raises, and describe how they will be addressed in your research. Also indicate the specific considerations that might be relevant to your application.

Reporting of ethical considerations*

This research proposal is mainly oriented towards mathematically oriented research without ethical challenges. As a successful project outcome contributes to stable operation of compressor devices, our results will contribute to reliable, precise and economic operation of these devices. We don't see any risk for abuse of the results.

The project includes handling of personal data

No

The project includes animal experiments

No

Account of experiments on humans

No

Research plan

Active Control of Compressor Systems Based on New Methods of Nonlinear Dynamic Feedback Stabilization

R. Johansson A. Shiriaev A. Robertsson L. Freidovich

March 31, 2015

1 Introduction and Research Status on Modeling and Active Controlling Compressor Systems

The analysis and control of airflow through a jet engine, or compressor, is a problem of great importance in current technology as manufacturers are under pressure to produce lighter, more efficient and safer jet engines. The related problem of flow control can easily be found in various other applications, where centrifugal and axial compressors are used. Actually, compressor systems are ubiquitous as technical components both in high-tech and mass market products. To mention a few, the reader could think of turbo-charging of internal combustion engines, air compression in gas turbines used in power plants, for marine propulsion, in pressurization and transportation of gas in pipelines *etc.* The flow is described by the three dimensional Navier-Stokes equations and these can be only approached numerically with current techniques, while it is a computationally very intensive problem, which hardly could help in design of an active airflow controller.

In 1986, Moore and Greitzer [13] introduced a simplified model of the flow through compressor that has become very successful, widely accepted and verified through experimental test: It consists of a partial differential equation (PDE) coupled with two ordinary differential equations (ODE). Over the last 2 decades many researchers have used low-order truncations of Fourier modes in the Moore-Greitzer equations. This has resulted in the three-state nonlinear ODE called the three-state Moore-Greitzer (3MG) model. The success of this model comes from the fact that it is able to cover qualitatively and quantitatively two limiting factors in performance of compression systems: *rotating stall* and *surge*.

Rotating stall develops when there is a region of stagnant flow rotating around the circumference of the compressor causing undesired vibrations in blades and reduced pressure rise in compressor. *Surge* is a large amplitude, axisymmetric flow oscillation in the compressor that can cause undesired vibration in other components of the compressor system and even damage the engine.

Active control of compressor systems has been a key objective for a number of research projects in industry and universities throughout the world. Available theoretical results on active control of compressor systems obtained for the last 10-15 years, are mainly concerned with the three-state Moore-Greitzer model and based on linearization, perturbation methods, bifurcation analysis, Lyapunov based methods and other approaches; and comprise an extensive list of references.

Most existing results are related to developing *state* (full information) feedback controllers, and are either not *cost-effective* or not directly *implementable*. To the best of our knowledge, there is no available solution based on an output feedback strategy that uses experimentally feasible measurements such as plenum pressure rise. Such attempts have been reported in [11], where the authors have claimed that their results have limited practical importance. The description of state of art, prospectives and similar conclusions can be found in [14].

The meager results of two decades of investigations clearly illustrate the difficulties and challenge of the posted example. It cannot be treated by existing methods, while any successful approach and fruitful observations could be readily followed by rich theoretical contributions and new product development. Such arguments motivate strongly further research activity on developing new methods for active *robust* control of compressor systems, and this is one of the primary objectives of the project.

2 General Difficulties and Approaches in Controlling Nonlinear Systems by Output Feedback

Controlling a nonlinear system by output measurements only is a difficult problem regularly encountered in practical applications, where internal states of the system are hidden from direct measurements, and therefore cannot be used for feedback control. This situation takes place in robotics, where position sensors are commonly in use, while (angular) velocities of different parts are usually not available.

Following the linear case the output feedback controller design for nonlinear dynamical system could be approached via the classical *separation principle*. Firstly, it suggests develoopment develop *separately* a full state feedback controller and a full state observer, and, *secondly*, choose as the output feedback controller the original full state controller with the observer state substituted instead of the unmeasured state of system. As for preliminary new results, see [21].

This principle works well for a large class of nonlinear control system, but unfortunately it does not hold for many cases met in practical applications. The reason for this is that the separate design of stabilizing a *full information* controller and a mechanism—*soft sensor*—for reconstructing the unmeasurable internal states of the system do not, in general, result in a successful output feedback controller. The three-state Moore-Greitzer compressor model is an illustrative example to this point, none of known full state controllers has been elaborated further to achieve an output feedback law that stabilizes the system. In other illustrative examples, the closed-loop system dynamics might blow up and grow unbounded in finite time, if one follows this controller design procedure.

This shows two main-streams in research for developing output feedback controllers

1. Description and search for classes of nonlinear control systems, for which the *separation principle* holds;

2. Developing new methods for output feedback controller design which are not based on the *separation principle* and avoid an explicit observer design step.

Both these problems are the key research topics of the project. The second item—developing output feedback controllers without an explicit observer design—is quite new for control methodology. It suggests to avoid explicit reconstruction of some physical quantities of the underlying process as an observer would do, but rather suggests to augment the process dynamics with some extention (dynamical controller), so that the closed-loop system satisfies some stability criteria.

In this project we are mainly interested in cases where the original nonlinear system could be augmented by a dynamical controller so that the closed-loop system satisfies one of *Integral Quadratic Constraints* stability tests (the IQC), for example, the classical Circle and Popov criteria, see [27, 25, 12, 16, 26].

As known, dynamical output feedback controllers derived for validity the IQC stability test is equivalent to solving the so-called Bilinear Matrix Inequalities (the BMI), that is a non-convex optimization problem difficult to handle [24]. Therefore, some of the problems posted in the project could be interpreted as description of closed-loop nonlinear systems, for which solvability of the corresponding BMI is feasible.

3 Challenges in Output Feedback Control Design for Moore-Greitzer Compressor Model

As emphasized above, the three-state Moore-Gretzer compressor model is an example of nonlinear dynamical system, for which output feedback design problem is open for almost 2 decades. The basic stumble for developing such controller is that the system dynamics is heavily nonlinear, coupled and its linearization around any of its operating points is not stabilizable. Indeed, the stall dynamics are not affected by control action directly and does not contain linear terms at all, so that any attempt to introduce linearized model for stall variable $R(t)$ fails into the trivial linear system $\dot{R} = 0$, which is not stabilizable!

This simple observation makes development of any (even locally) stabilizing controller potentially difficult and nontrivial: the stability of the closed-loop system with any controller, if needs to be checked, cannot be done via linearizing the closed-loop dynamics.

A further difficulty and challenge in developing output feedback controller for the three-state Moore-Greitzer model is that practical use of such a controller should be *robust* with respect to various uncertainties in the open-loop system. Indeed, the discussed three-state ODE model has been obtained via number of simplifications and approximation steps in the calibrated model of the compressor system. Having in mind that this controller would be applied for real compressor systems, it should possess fairly good stability and robustness margins to succeed.

4 Objectives of the Project

The goal of the project is to consider and solve listed below theoretical control problems; to extend and elaborate further these results for practically important examples having the main focus on the compressor systems. They are:

- Synthesis of *robust dynamical output feedback controllers* for nonlinear systems based on the *Integral Quadratic Constraints* stability methods [20, 19];
- Solution of the *Bilinear Matrix Inequalities* associated with output feedback controller design via decomposition and reduction to known convex problems;
- Design of *reduced* and *full state observers* for nonlinear controlled systems [5, 7];
- Descriptions of new classes of nonlinear controlled systems, for which the *separation principle* holds [21, 8];
- Design of robust dynamical feedback controllers by output (that is *a plenum pressure rise*) for the three-state Moore-Greitzer compressor model. [22]

with preliminary results already reported [20, 19, 5, 7, 21, 22].

5 Current Status and Available Results

The studies have been based on regular communications, discussions and collaborative meetings of applicants for the last eight years and have been previously supported by the Research Council. During this period we have been able to solve several challenging problems, which—we believe—brought us to the unique position and knowledge to complete and report the solution in the nearest future. Namely, the following novel structural properties of the three-state Moore-Greizter compressor model were found:

1. *Integrability of stall dynamics:* Despite the fact that time evolution of stall is strongly nonlinear we showed that its value can be computed analytically for any (bounded or unbounded) solution of the three-state Moore-Greitzer model with any (state, output or dynamic) feedback controller since the differential equation for this variable can be explicitly integrated [19, 20]. This fact has not been reported earlier and plays an essential role in our approach for state and output feedback design;
2. *Novel test of local asymptotic stability or instability of the system's origin augmented with dynamic (state or output) feedback controller:* Since the linarization of stall dynamics at the origin is marginally stable for any controller, then the linearization the closed-loop system with any controller at this point is not decisive for stability or instability. To succeed, we have considered high-order terms in expansion of the closed-loop system and used the transformation of the coordinates and the central manifold arguments to reach an affirmative conclusion on stability or instability. The criterion is formulated from inequalities on coefficients of a controller. In addition, the arguments show the cases of exponential convergence of most important physically meaningful variables—averaged mass-flow and pressure rise—to the nominal values even though the stall and some controller states might decay with different speed.

These two contributions have been complemented by two new general stability tests appeared important for design output dynamic controller for robust stabilization of

the surge subsystem. Both tests assume the separation of the dynamics into two x- and e-subsystems, which—if considered individually—are stable. However, they are coupled and stability of the overall system is investigated. We classify the stability criteria by the form of IQCs nonlinearities in the closed-loop system satisfy:

1. *The case of strict IQCs*: Assuming that both x-and e-subsystems are quadratically stable, we have been able to use the structural form of coupling between two subsystems and reconstruct the Lyapunov function for the combination;

2. *The case of non-strict IQCs*: Assuming that e-subsystem is quadratically stable while x-subsystem is just asymptotically stable, we have been able to use the structural form of coupling between two subsystems and prove asymptotic stability for the combination;

The division of the state into sub-systems is important and represent the constructive approach for solving BMIs associated with dynamic (state or output) feedback design for the surge subsystem decomposed into two convex problems. The subsystems do not necessary correspond to observer and state feedback designs. I.e. in examples e-subsystem that would label the error dynamics for estimator of missing mass-flow measurement, can have arbitrary number of states and do not admit usual interpretation. In this way we have overcome known difficulties with establishing *the separation principle* for the compressor model. And, we use and interpret the proposed decomposition as certain type of matching conditions for dynamic controller to succeed in stabilization of the surge subsystem of the Moore-Greitzer model. These matching conditions include:

1. A choice of a parametric family of feedback controller;

2. Sorting the states of the closed-loop system that might be linearly equivalent to x-and e-subsystems done by analysis of present nonlinearities and known for them IQCs;

3. Checking validity of the *frequency condition* for the x-and e-subsystems [25, 26]. This results in description of parameters for controllers that potentially stabilize the overall system;

4. Checking a form of coupling between subsystems to meet conditions of one of two general statements and derive a subset of the found on Step 3 feedback controllers that will be stabilizing for the surge subsystem.

These steps have been successfully repeated for several classes of static and dynamic, state and output feedback laws with matched nonlinearities. And we have derived the rich description of a families of new stabilizing controllers that solve the task.

Our next investigation has been focused on analysis of dynamics of 3MG compressor model augmented with controllers developed for robust stabilization of the surge. It has been shown that unfortunately even quadratic stabilization of the surge subsystem is not sufficient and nontrivial stall dynamics can indeed destabilize the origin of closed-loop system and bring both new new steady states and new limit cycles into dynamics. To this end we proposed the following contributions in analysis of the 3MG model:

1. We have presented arguments how *analytically* to introduce a Poincaré section for analysis of cycles of the closed-loop system;

2. We have found the class of dynamical controllers stabilizing the surge that possess an integrator as of its states and using integrability of stall dynamics we have shown the absence of induced cycles in the closed-loop system even the stall has nontrivial dynamics.

3. We have found new IQCs for the stall dependent nonlinearity in dynamics of mass-flow variable and succeeded in establishing the following fundamental result: *For a class of dynamic state feedback controllers with an integrator that stabilize the surge system, these controllers ensure global robust asymptotic stability of the whole three-state Moore-Greitzer model with nontrivial stall dynamics provided the closed-loop system has no other equilibrium except at the origin [18].*

All the presented results are very recent and just partly reported, see [22, 23, 8]. However, we strongly believe that further investigation will allow establishing the similar result for output feedback design and bring the constructive description of such controllers for the first time.

As other general contributions to the topic we would like to mention a recent contribution to variable-structure control based on state estimation [9].

The conditions mentioned for solvability of the BMI and its reduction to convex optimization problems are the conditions that ensure applicability of *separation principle* for reduced order observer-state feedback design. The quadratic constraint written in incremental form for such closed loop system is exactly used for proving stability of error dynamics with particular reduced-order observer embedded into the closed loop system. At the same time monotonicity of nonlinearity is used for design robustly stabilizing state-feedback controller for the original system. The method suggests the way to combine these two facts: stabilized reduced-order observer error dynamics and state-feedback design, and results in description of a set of robustly stabilizing dynamic output feedback controllers. Typically, stabilizing controllers derived through *separation principle* correspond to low dimensional sub-manifold in the state-space of parameters of controllers with the structure fixed at the beginning of design procedure [18, 7, 21];

6 Organization and Cost of the Project

The project is planned for 3 years, starting the 1st January 2016 till 31st December 2018. It is planned that in case of approval and support from the VR the project will cover the following expenses:

- the salary of a PhD student, which will be supervised by Prof. R. Johansson and co-supervised by Prof A. Shiriaev and Dr. A. Robertsson for 3 years;

- Operational expenses to cover co-supervisory work;

It is anticipated that these expenses would allow:

- To organize and support strong research activity addressing a difficult theoretical problem of robust output feedback design;
- To develop a new approach for synthesis of robust output controllers for class of nonlinear control system including important practical examples, like flow control in a jet engines, gas turbines and turbo-charging of internal combustion engines in cars;
- To publish 5-6 papers in leading international journals on the subject;
- To visit, to establish and to strengthen fruitful collaboration with leading research labs working on subject in academia (Prof. Anton Shiriaev, Dept. Engineering Cybernetics, NTNU, Trondheim) and in industry (Cecost, Siemens, Volvo Aero, whose researchers have expressed an interest to follow our work) with intention to exchange and potentially commercialize the research results.

7 International Network of Participants and Ongoing Collaborations

Controlling nonlinear systems, feedback stabilization, stability and optimization are main subjects of PhD-thesis, post-doctoral activity and current research activity of Prof. A.S. Shiriaev, NTNU. This research is done and relies on strong connections and active collaborations with several research groups (in control and applied mathematics) in academia including St. Petersburg State University, Russia (Prof. Yakubovich V.A., Prof. Leonov G.A., Prof Fradkov A.L.) and University of Texas at Dallas (Prof. Spong M.W., Prof. Vidyasagar M.).

The research on output feedback control and observers was the thesis topic of Dr Robertsson and his international cooperation in this area comprise Dr E. Lefeber, TU Eindhoven, the Netherlands, Prof. M. Verhaegen, TU Delft, the Netherlands, Prof. H. Nijmeijer, TU Eindhoven, the Netherlands, Prof. R. Lozano, Compiègne, France, Prof. A. Krischenko, and Prof. S. Tkachev, Baumann Institute, Moscow, Russia.

Department of Automatic Control (www.control.lth.se), Lund University is known worldwide for its contributions to adaptive control, system identification, real-time systems, modeling and simulation of dynamical systems. Our laboratory has well established research ranging from theory, methodology to applications in control theory, mathematical modeling and system simulation, system identification, extraction of mathematical models from experimental data, nonlinear system theory, adaptive and learning control and with activity in theory methodology as well as application. Current research involves about 60 scientists and experimental facilities, in particular, Robotics Laboratory that is designed as an open laboratory for scientific cooperation. Our department receives many visiting scientists attracted by the mix of theoretical, experimental and industrial problems treated at our laboratory. The international attention to our department is also witnessed by various international invitations received by our coworkers. In April 2004, Rolf Johansson was invited to UC Berkeley, Dept. Mechanical Engineering as Russell S. Springer Visiting Professor; in 2007 to Supélec, Gif-sur-Yvette, France; and in 2010 to A*STAR, Singapore.

Another important collaboration is with the Competence Center of Combustion Precesses (KCFP) where Rolf Johansson acts as a subproject leader. Application of the project results to automotive turbocharging is one idea which could foresee experimental application within KCFP.

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Interdisciplinarity

My application is interdisciplinary

☐

An interdisciplinary research project is defined in this call for proposals as a project that can not be completed without knowledge, methods, terminology, data and researchers from more than one of the Swedish Research Councils subject areas; Medicine and health, Natural and engineering sciences, Humanities and social sciences and Educational sciences. If your research project is interdisciplinary according to this definition, you indicate and explain this here.

Click here for more information

Scientific report

Scientific report/Account for scientific activities of previous project

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Budget and research resources

Project staff

Describe the staff that will be working in the project and the salary that is applied for in the project budget. Enter the full amount, not in thousands SEK.

Participating researchers that accept an invitation to participate in the application will be displayed automatically under Dedicated time for this project. Note that it will take a few minutes before the information is updated, and that it might be necessary for the project leader to close and reopen the form.

Dedicated time for this project

	Role in the project	Name	Percent of full time
1	Applicant	Rolf Johansson	10
2	Other personnel without doctoral degree	Doktorand	80
3	Participating researcher	Leonid Freidovich	

Salaries including social fees

	Role in the project	Name	Percent of salary	2016	2017	2018	Total
1	Applicant	Rolf Johansson	5	87,000	89,000	91,000	267,000
2	Other personnel without doctoral degree	Doktorand	80	622,000	638,000	654,000	1,914,000
	Total			709,000	727,000	745,000	2,181,000

Other costs

Describe the other project costs for which you apply from the Swedish Research Council. Enter the full amount, not in thousands SEK.

Premises

Type of premises	2016	2017	2018

Running Costs

	Running Cost	Description	2016	2017	2018	Total
1	Materials	Materials	100,000	100,000	100,000	300,000
2	Computing cost	Computing cost	100,000	100,000	100,000	300,000
3	Travel	Travel	50,000	50,000	50,000	150,000
	Total		250,000	250,000	250,000	750,000

Depreciation costs

Depreciation cost	Description	2016	2017	2018

Total project cost

Below you can see a summary of the costs in your budget, which are the costs that you apply for from the Swedish Research Council. Indirect costs are entered separately into the table.

Under Other costs you can enter which costs, aside from the ones you apply for from the Swedish Research Council, that the project includes. Add the full amounts, not in thousands of SEK.

The subtotal plus indirect costs are the total per year that you apply for.

Total budget

Specified costs	2016	2017	2018	Total, applied	Other costs	Total cost
Salaries including social fees	709,000	727,000	745,000	2,181,000		2,181,000
Running costs	250,000	250,000	250,000	750,000		750,000
Depreciation costs				0		0
Premises				0		0
Subtotal	959,000	977,000	995,000	2,931,000	0	2,931,000
Indirect costs	422,000	430,000	438,000	1,290,000		1,290,000
Total project cost	1,381,000	1,407,000	1,433,000	4,221,000	0	4,221,000

Explanation of the proposed budget

Briefly justify each proposed cost in the stated budget.

Explanation of the proposed budget*

The proposal is oriented towards support for one graduate student and for supporting advisory work and research participation for the project leader and graduate advisor. Materials, computing costs and travel cost are ordinary budgets to support conference presentations and travel to cooperation partners. Current over-head cost for Lund university is 44%. Justification for salary costs is givenn below (in Swedish).

Befattning / månad	Lön	Lönebikostnad	Indirekt kostnad	Lönerevision
Pålägg		1.5	1.44	1.025
Professor	66,500	99,750	143,640	147,231
Doktorand	30,000	45,000	64,800	66,420

Other funding

Describe your other project funding for the project period (applied for or granted) aside from that which you apply for from the Swedish Research Council. Write the whole sum, not thousands of SEK.

Other funding for this project

Funder	Applicant/project leader	Type of grant	Reg no or equiv.	2016	2017	2018

CV

Curriculum Vitae of Dr. Rolf Johansson

Dept. Automatic Control., Lund Institute of Technology, Lund University, PO Box 118, S-221 00 Lund; Phone +46 46 222 8791; Fax +46 46 138118; Email Rolf.Johansson@control.lth.se

1. **University Exams:** Master of Science, Technical Physics, Lund University 1977; Bachelor of Medicine, Lund University, 1980; Doctor of Medicine (M.D.), Lund University, 1986;
2. **Doctorate:** 1983, Control theory, (Title: *Multivariable Adaptive Control*);
3. **Post-doctorate Research:** 1985, Centre National de la Recherche Scientifique (CNRS), ENSIEG, INPG, Grenoble, France under the NFR-CNRS bilateral agreement;
4. **Associate Professor (Docent):** 1985, Uppsala University; 1986 Associate Professor, Lund University;
5. **Professional Position:** Professor, Dept. Automatic Control, Lund University, Appointed 1999 (no specific time for research);
6. **Previous Professional Appointments:**
   - Associate Professor, 1 January 1986; Professor, Control Science, Lund University, 1999;

   Visiting research appointments:

   1. Visiting scientist CalTech, Pasadena, CA, June 1997, June 2001;
   2. Rice Univ., Houston, TX, May 1998, May 2001;
   3. Supélec, Paris, France, June 1998;
   4. Univ. Illinois at Urbana-Champaign, IL, 1999;
   5. Univ. California, Santa Barbara, CA, Aug. 1999;
   6. Univ. Napoli Fed II, Politecnico Milano, July 2000;
   7. Norwegian Univ. Science & Technology, Trondheim, Norway, August 2001;
   8. Univ. Colorado at Boulder, CO, June 2002;
   9. Univ. Newcastle, Newcastle, New South Wales, Australia, July 2003;
   10. Tsinghua Univ., Beijing, China, Nov. 2003, Aug. 2004;
   11. Russell S. Springer Visiting Professor 2004, University of California, Berkeley, CA, April 2004;
   12. Universidad de Jaén, Jaén, Spain, July 2005.
   13. Professeur Invité, Laboratoire des Signaux et Systèmes (LSS)—CNRS, Supélec, France, June 2007;
   14. SIMTech Fellow, 2010, 2011; SIMTech, A*Star, Singapore
7. **Military Service:** Defence Language School, Uppsala, 1975-1976; Russian (40 cr.); Political Science (40 cr.);
8. **Graduate Advisorships:** Johan Bengtsson (2004), Krister Brantberg (1991), Jonas Carlsson (2005, Marzia Cescon (2013), Håkan Enbom (1990), Per Anders Fransson (2005), Javier Gámez García (2006), Maria Henningsson (2012), Magnus Holm (1997), Ola Johansson (2009), Mikael Karlberg (1995; 1995 Crafoord Prize for best doctoral dissertation), Magnus Linderoth (2013), Klas Nilsson (1996), Tomas Olsson (2007), Serge Padouan (1992), Hannes Petersen 1995), Anders Robertsson (1999), Per Tunestål (2001), Anders Widd (2012)

Awards and Honors:

1. IEEE Fellow, Citation: For contributions to system identification and adaptive control; 26 Nov 2012
2. Best Automation Paper Award from the 2012 IEEE International Conference on Robotics and Automation (ICRA2012), Saint Paul, MN, May 14-18, 2012, presented on 17 May 2012
3. Best Paper Award from the *13th IFAC Symp. Inf. Control Problems in Manufacturing (INCOM'09)*, Moscow, Russia, June 3-5, 2009.
4. *Euron/EUnited Robotics Technology Transfer Award 2007, Third Prize—Cost-effective Drilling Using Industrial Robots with High-Bandwidth Force Feedback* (shared with a research group of members from Lund University, Linköping University, ABB Robotics and Saab Aircraft—Tomas Olsson, Mathias Haage, Henrik Kihlman, Torgny Brogårdh, Klas Nilsson, Anders Robertsson, Robert Isaksson, Gilbert Ossbahr, Mats Björkman, Magnus Engström, Rolf Johansson)
5. Fellow of *Kgl. Fysiografiska Sällskapet* (*Royal Physiographic Society*), Section of Medicine, April 2007
6. *Euron Technology Transfer Award 2004* (shared with a research group of members from LTH, Automatic Control, LTH, Computer Science—Anders Blomdell, Mathias Haage, Rolf Johansson, Klas Nilsson, Tomas Olsson, Anders Robertsson—and ABB—Torgny Brogårdh, Tomas Groth, Mats Isaksson, Stig Moberg, Sven Hanssen, Hui Zhang, Jian Jun Wang, Håkan Brantmark);

7. Honorary Visiting Professor, Wuhan University of Science and Technology (WUST), Wuhan, Hubei, China, 2004;
8. Russell S. Springer Visiting Professor 2004, University of California, Berkeley, Berkeley, CA;
9. Honorary Visiting Professor, North China University of Science and Technology (NCUST), Taiyuan, Shanxi, China, 2003;
10. Recipient of the Biomedical Engineering Prize (*Ebeling Prize*) of the Swedish Society of Medicine, 1995 (for distinguished contribution to the study of human balance through application and development of system analysis and robotics);
11. Included in *Who's Who in the World*, 12th ed., 1994, p. 679; *Who's Who in Science and Engineering*, 3rd Ed., p. 479; *Who's Who in Medicine*, 2nd Ed., p. 414;
12. *Innovation Cup '88* regional award by *Skandia* and *Dagens Industri* 1988

Research Cooperation (see also visiting research appointment above):

1. Dr. Klas Nilsson, Dept. Computer Science, Lund University, 1996--present
2. Dr. Alberto Herreros, U. Valladolid, Spain, Postdoctorate researcher, 2004;
3. Prof. Bengt Johansson, Div. Combustion Engines, Lund University, 2001--present;
4. Prof. A. P. Krishchenko, S. B. Tkachev, Dept. Mathematics, Bauman Inst. Moscow, Russia;
5. Prof. R. Lozano, Université de Technologie de Compiègne, Compiègne, France, 1998--present;
6. Prof. Måns Magnusson, Div. Otorhinolaryngology, Dept. Clinical Sciences, Lund University, 1986--present;
7. Prof. S. Bertil Olsson, Div. Cardiology, Dept. Clinical Sciences, Lund University, 1991--present;
8. Prof. Anton Shiriaev, Umeå University, 1998--present;
9. Prof. Michel Verhaegen, TU Delft, 1996--present;
10. Prof. Zhou Zhaoying, Tsinghua University, Beijing, China, 1979--present;

Membership of International Program Committees, Award Committees:

1. Associate editor of IEEE CDC&ACC Conference Editorial Board 1997—2000;
2. Associate Editor *J. Adaptive Control & Signal Processing*. 1999—;
3. IPC member of AIM2001, M2VIP 2001, AIM2003, M2VIP2003, ICRA2003, AAC04, ICRA2004, ACC2005, CIRA2005, ICRA2005, ICCV2005, Control 2006, Controlo'2006, IROS 2006, ECCV2006, CDC 2006, EMBC2006, AIM 2007, M&R-2007, ROBOCOMM 2007, CISIPN 2007, Control 2008, Controlo'2008, Automatics 2008, CDC08, INCOM2009, SYROCO 2009, E-COSM'09, ROBOCOMM 2009, ICCV 2009, ROBIO 2010, ICRA 2011, IROS 2011, IRoA-11, ROBIO 2011, E-COSM'12, Controlo'2012
4. Member of IEEE-CSS Technical Activity Board on Automotive Control; IEEE-CSS Biosystems and Control;
5. Member of IEEE TCST Outstanding Paper Award Committee 2003
6. Member of IEEE EMBS Technical Committee (TC) for Biomedical Robotics
7. Member of Joint EMBS/RAS Advisory Committee on Biorobotics,
8. Program Chair Europe and Member of the Executive Committee of The First IEEE RAS/EMBS International Conference on Biomedical Robotics and Biomechatronics (BioRob 2006)
9. Associate Editor (Invited Papers), 47th IEEE CDC08, Cancun, Mexico, December 2008
10. Editor for Modeling, 47th IEEE Conference on Decision and Control (CDC08), Cancun, Mexico, December 2008
11. Program Co-Chair of 2009 IEEE Int. Conf. Robotics and Biomimetics (ROBIO 2009), Guilin, Guangxi, China, Dec 12-15, 2009
12. Advisory Committee Member, IEEE RAS-EMBS BioRob 2006, BioRob 2008, BioRob 2010, BioRob 2012
13. Member of scientific evaluation committees: NFR, VR, SFI, NRC, ECFP7-NMP, ECFP7-ICT;
14. Member of Networks of Excellence NACO, HYCON, HYCON2; Competence Center KCFP;
15. Co-recipient of Swedish Research Council (VR) Linnaeus grant 2008 LCCC (Excellence Center);
16. Work package leader in ECFP7 projects DIAdvisor, ROSETTA, SMErobotics;

Other:

1. Private pilot license 1977; US Private pilot license 1978;
2. Faculty representative in the Board of studies for Technical Physics, Electrical Engineering, and Computer Science, 1986-1993; Director of Studies, Control theory, 1986-96; Chairman of mathematics curricula for computer science major, Lund Inst. Technology during 1989-1990; External examiner in dissertations for doctorate and licentiate degrees;
3. Development of new regular graduate courses FRT040 System Identification and FRT075 Nonlinear Control. Postgraduate courses in system identification, optimal control, adaptive control; Vestibular Lab, ENT, Lund Univ.; Thesis advisor of 17 Ph.D:s and 170 M.Sc. and current thesis advisor of ten PhD-students; Postdocs: A. Herreros, R. Lenain; Coordinating Director of Nutek-supported robotics research in Lund 1993-2000;
4. Principal investigator or node leader in projects DIAdvisor, ROSETTA, LCCC;

CV / scientific qualifications

1. Higher education degree

- **M.Sc. in Engineering:** *February 1996* – Department of Mechanics and Control Processes, *St. Petersburg State Technical University*, Russia.

2. Doctoral degrees

- **Kandidat of Physical and Mathematical Sciences:** *June 1999* – Department of Mechanics and Control Processes, *St. Petersburg State Technical University*, St. Petersburg, Russia; thesis: "Stability and Control of Robotic Manipulators"; supervisor: Prof. A.A. Pervozvanski.
- **Ph.D. in Mathematics:** *March 2005* – Department of Mathematics, *Michigan State University*, USA; thesis: "Logic-Based Switching Control of Nonlinear Systems Using High-Gain Observers"; supervisor: Prof. H.K. Khalil.

3. Postdoctoral positions – *none (nonstandard career path: two Ph.D. degrees instead of post-doctoral positions)*

4. Qualification as an associate professor

- **Docent in Control Systems:** *October 2010* – Faculty of Science and Technology, Umeå University, Umeå, Sweden.

5. Current position

- **Associate Professor** [universitetslektor]: since March 2009, permanent (tillsvidareanställning), share of time spent in research is 80% until the end of 2015, Department of Applied Physics and Electronics, Umeå University, Umeå, Sweden.

6. Previous positions and periods of appointment

- **Assistant Professor** [forskarassistent]: *March 2005 – March 2009*, Department of Applied Physics and Electronics, Umeå University, Umeå, Sweden.
- **Graduate Research Assistant** (part-time): *December 2004 – March 2005*, Department of Electrical and Computer Engineering, Michigan State University, East Lansing, USA.
- **Graduate Teaching Assistant** (half-time): *August 1997 – March 2005*, Department of Mathematics, Michigan State University, East Lansing, MI, USA.
- **Research Assistant** (part-time): *1993 – 1997*, Department of Mechanics and Control Processes, St. Petersburg State Technical University, St. Petersburg, Russia.
- **Research Assistant** (part-time): *1994 – 1995*, State Scientific Centre, Central Research and Design Institute for Robotics and Technical Cybernetics, St. Petersburg, Russia.

7. Interruptions in research

- Parental leaves (approx. 3 months): May 22 – June 1, 2007; August 1 – 31, 2008; September 22 – 30, 2008; October 1 – 14, 2010, June 11 – August 6, 2012.

8. Supervision (main advisor, completed)

- Stanislav Aranovskiy, post-doc: 2012-2014.

9. Supervision (co-advisor, completed)

- Uwe Mettin: December 2009 (main advisor: Prof. Anton Shiriaev),

- Pedro Xavier Miranda La Hera: March 2011 (main advisor: Prof. Anton Shiriaev),
- Daniel O. Morales: January 2015 (main advisor: Prof. Anton Shiriaev),

10. Active supervision duties (on-going)

Currently, I am the main advisor for 2 Ph.D. students (Szabolcs Fodor and I Yung Ong) and 1 post-doc (Carlos Vázques).

11. Scientific outcome (1996-2015):

- **35** peer-reviewed journal articles; **58** peer-reviewed international conference contributions; **2** books and **2** book chapters.
- Google scholar page: http://scholar.google.com/citations?user=VBekdAUAAAAJ

12. Fields of research expertise / interests

(A) Control Design for Nonlinear Systems; (B) Stability Analysis for Nonlinear Systems; (C) Robot Control and Robotics; (D) Feedback Control of Mechanical Systems; (E) Design of Observers; (F) Trajectory Planning for Underactuated Mechanical Systems.

13. Research network and main research collaborators

• ***Prof. Anton S. Shiriaev***, Norwegian University of Science and Technology, Norway and Umeå University, Sweden (same research group in 2005-2010); • ***Prof. Anders Robertsson***, LTH, Lund University, Sweden (visited: August 28-31 and November 13-18, 2005, June 26-30 and August 25-31, 2006); • ***Prof. Rolf Johansson***, LTH, Lund University, Sweden (visited: same as for A. Robertsson); • ***Prof. Hassan K. Khalil***, Michigan State University, USA (Ph.D. and M.Sc. advisor); • ***Dr. Ilya V. Burkov***, St. Petersburg State Polytechnic University, Russia (M.Sc. co-advisor); • ***Prof. Francisco Gordillo***, University of Seville, Spain (visited: May 17-23, 2010); • ***Dr. Fabio Gómes-Estern***, University of Seville, Spain; • ***Prof. Mark W. Spong***, University of Texas at Dallas, USA; • ***Dr. Sergei V. Gusev***, St. Petersburg State University, Russia; • ***Prof. Leonid M. Fridman***, Universidad Nacional Autónoma de México, Mexico (visited: June 1-July 31, 2010); • ***Prof. Jakob Stoustrup***, Aalborg University, Denmark (visited: August 14-24, 2006); • ***Prof. Takayuki Takahashi***, Fukushima University, Japan (visited: August 17-19, 2007 and March 15-22, 2008); • ***Dr. Christine Chevallereau***, Institut de Recherche en Communications et Cybernétique de Nantes, France (visited: September 24-29, 2007); • ***Prof. Alexander L. Fradkov***, Institute for Problems of Mechanical Engineering, Russian Academy of Sciences, St. Petersburg, Russia; • ***Dr. Giuseppe Oriolo***, Università di Roma, Italy; • ***Dr. Denis Efimov***, INRIA, Lille, France.

14. Honors and Awards

• Track Programme Committee (TPC) member for the three IEEE Emerging Technologies and Factory Automation Conferences: Italy 2013, Spain 2014, and Luxemburg 2015; • Steering Committee (SC) members for the IEEE/IES International Conference on Mechatronics, Japan 2015; • International Programme Committee (IPC) member for the 14th Mechatronics Forum International Conference, Sweden 2014; • Senior member of IEEE (2011); • IPC member for the 11th International Workshop on Variable Structure Systems, Mexico 2010; • Travel grant from Swedish Research Council to visit UNAM; • Career grant "Young Researcher Award" (Karriärbidrag) from Umeå University, 2009-2011; • Selected into the final list of 5 for 2009 Guan Zhao-Zhi Award; • Best presentation award on 2009 American Control Conference; • Scholarships from Open Society Institute (International Soros Science Education Program, grants a97-1503 and s96-2061), 1997 and 1996; • Reviewer for MathSciNet and for many international journals and conferences within the fields of Control Systems and Robotics.

Publication list

Publications 2007-2014 of Dr. Rolf Johansson

Dept. Automatic Control, Lund University, PO Box 118, S-221 00 Lund; Phone +46 46 222 8791; Fax +46 46 138118; Email Rolf.Johansson@control.lth.se

Citations are given according to Google Scholar; >300 publications as of April 2015; **H-index: 40**

1. Referee Reviewed Papers

1. D. Blom, M. Karlsson, K. Ekholm, P. Tunestal, R. Johansson, HCCI Engine Modeling and Control using Conservation Principles, ***SAE Technical Papers 2008-01-0789***, April 2008; also in ***Homogeneous Charge Compression Ignition (HCCI) Combustion 2008, SAE Special Publication SAE SP-2182***, SAE, Warrendale, PA, ISBN 978-0-7680-2024-3 [Number of citations: 22]
2. J. Collado, R. Lozano, and R. Johansson, Using an Observer to Transform Linear Systems Into Strictly Positive Real Systems, ***IEEE Transactions on Automatic Control,*** Vol. 52, No. 6, June 2007, pp. 1082-1088 [Number of citations: 67
3. M. Cescon, R. Johansson, E. Renard and A. Maran. Identification of Individualised Empirical Models of Carbohydrate and Insulin Effects on T1DM Blood Glucose Dynamics, ***International Journal of Control***, 2014 [Number of citations: 0]
4. K. Ekholm, M. Karlsson, P. Tunestal, R. Johansson, B. Johansson, P. Strandh, Ethanol-Diesel Fumigation in Multi-Cylinder Engine, ***SAE Technical Papers 2008-01-0033***, April 2008; also in ***Homogeneous Charge Compression Ignition (HCCI) Combustion 2008, SAE Special Publication SAE SP-2182***, SAE, Warrendale, PA, ISBN 978-0-7680-2024-3 [Number of citations: 2]
5. P.-A. Fransson, M. Hjerpe, R. Johansson, Adaptation of multi-segmented body movements during vibratory proprioceptive and galvanic vestibular stimulation, ***J. Vestibular Research***, Vol. 17, No. 1, pp. 47-62, 2008. [Number of citations: 19]
6. L. Freidovich, A. Shiriaev, A. Robertsson, and R. Johansson, LuGre-Model-Based Friction Compensation, ***IEEE Transactions on Control Systems Technology***, Vol. 18, No. 1, pp. 194–200, 2010 [Number of citations: 53]
7. L. Freidovich, A. Robertsson, A. Shiriaev, R. Johansson, Periodic motions of the Pendubot via virtual holonomic constraints: Theory and experiments, ***Automatica***, Vol. 44, No. 3, 2008, pp. 785-791. [Number of citations: 45]
8. L. Freidovich, P. La Hera, U. Mettin, A. Robertsson, A. Shiriaev, R. Johansson, Shaping Stable Periodic Motions of Inertia Wheel Pendulum: Theory and Experiments, ***Asian Journal of Control***, Vol. 11, No. 5, pp. 548-556, 2009 [Number of citations: 6]
9. J. Gámez García, A. Robertsson, J. Gómez Ortega, and R. Johansson, Estimación de la Fuerza de Contacto para el Control de Robots Manipuladores con Movimientos Restringuidos (Contact Force Estimation for Compliant Motion Control), ***Revista Iberoamericana de Automática e Informática Industrial***, Vol. 4, No. 1, pp. 70-82, 2007 [Number of citations: 7]
10. J. Gámez García, A. Robertsson, J. Gómez Ortega, R. Johansson, Self-Calibrated Robotic Manipulator Force Observer, ***Robotics and Computer-Integrated Manufacturing***, Vol. 25, No. 2, pp. 366-378, 2009. [Number of citations: 7]
11. J. Gámez García, A. Robertsson, J. Gómez Ortega, R. Johansson, Sensor Fusion for Compliant Robot Motion Control, ***IEEE Transactions on Robotics***, Vol. 24, No. 2, 2008, pp. 430-441. [Number of citations: 37]
12. S. Gomez, M. Patel, S. Berg, M. Magnusson, R. Johansson, P. A. Fransson, Effects of proprioceptive vibratory stimulation on body movement at 24 and 36 h of sleep deprivation, ***Clinical Neurophysiology***, Vol. 119, No. 3, pp. 617-625. [Number of citations: 17]

13. M. Henningsson, B. Bernhardsson, P. Tunestål, R. Johansson. A Machine Learning Approach to Information Extraction from Cylinder Pressure Sensors, ***SAE Technical Paper*** 2012-01-0440, 2012 [Number of citations: 2]
14. A. Herreros, E. Baeyens, R. Johansson, J. Carlson, J. R. Perán, S. B. Olsson, Analysis of Changes in the Beat-to-Beat P-wave Morphology Using Clustering Techniques, ***Biomedical Signal Processing and Control***, Vol. 4, pp. 309–316, 2009. [Number of citations: 8]
15. A. Herreros, E. Baeyens, P. Riverta, Rolf Johansson. Performance Improvement of a Phase Space Detection Algorithm for Electrocardiogram Wave Morphology Classification, ***Journal of Electrocardiology***, Vol. 44, No. 2, March-April 2011 [Number of citations: 8]
16. (*) R. Johansson, P. A. Fransson, M. Magnusson, Optimal Coordination and Control of Posture and Movements, ***Journal of Physiology—Paris***, Vol. 103, No. 3-5, pp. 159-177, 2009. [Number of citations: 10]
17. H. Kirchsteiger, R.Johansson, E. Renard, L. del Re, Continuous-Time Interval Model Identification of Blood Glucose Dynamics for Type 1 Diabetes, ***International Journal of Control***, 2014 [Number of citations: 0]
18. T. Olsson, M. Haage, H. Kihlman, R. Johansson, K. Nilsson, A. Robertsson, M. Björkman, R. Isaksson, G. Ossbahr, T. Brogårdh, Cost-Efficient Drilling Using Industrial Robots with High-Bandwidth Force Feedback, ***Robotics and Computer-Integrated Manufacturing***, Vol. 26, pp. 24-38, 2010. [Number of citations: 33]
19. M. Patel, P. A. Fransson, D. Lush, H. Petersen, M. Magnusson, R. Johansson, S. Gomez,The Effects of Foam Surface Properties on Standing Body Movement, ***Acta Otolaryngologica***, 128:9, pp. 952-960, September 2008. [Number of citations: 13]
20. M. Patel, S. Gomez, S. Berg, P. Almbladh, J. Lindblad, H. Petersen, M. Magnusson, R. Johansson, P. A. Fransson, Effects of 24-h and 36-h Sleep Deprivation on Human Postural Control and Adaptation, ***Experimental Brain Research***, 185:2, pp. 165-173, April 2008. [Number of citations: 35]
21. M. Patel, P. A. Fransson, R. Johansson, M. Magnusson, Foam Posturography: Standing on Foam is not Equivalent to Standing with Decreased Rapidly Adapting Mechanoreceptive Sensation, ***Experimental Brain Research,*** 2010. [Number of citations: 15]
22. Sang Hyoung Lee, Il Hong Suh, S. Calinon, R. Johansson, Autonomous Framework for Segmenting Robot Trajectories of Manipulation Task, ***Autonomous Robots***, 2014.
23. U. Schneider, B. Olofsson, O. Sörnmo, M. Drust, A. Robertsson, M. Hägele, R. Johansson, Integrated Approach to Robotic Machining with Macro/Micro-Actuation, ***Robotics and Computer-Integrated Manufacturing***, Vol. 30, No. 6, 2014, pp. 636-647.
24. A. S. Shiriaev, L. B. Freidovich, A. Robertsson, R. Johansson, A. Sandberg, Virtual-Holonomic-Constraints-Based Design of Stable Oscillations of Furuta Pendulum: Theory and Experiments, ***IEEE Transactions on Robotics,*** Vol. 23, No. 4, 2007, pp. 827 - 832 [Number of citations: 42]
25. A. Shiriaev, L. Freidovich, R. Johansson and A. Robertsson, Global Stabilization for a Class of Coupled Nonlinear Systems with Application to Active Surge Control, ***Dynamics of Continuous, Discrete and Impulsive Systems, Series B: Applications & Algorithms***, (Special Issue in honor of Professor Hassan K. Khalil's 60th Birthday), Vol. 17, No. 6, 2010, pp. 875-908 [Number of citations: 5]
26. (*) F. Ståhl, R. Johansson, Diabetes Mellitus Modeling and Short-Term Prediction Based on Blood Glucose Measurements, ***Mathematical Biosciences,*** Vol. 217, pp. 101-117, 2009. [Number of citations: 51]
27. A. Widd, K. Ekholm, P. Tunestål, R. Johansson. Physics-Based Model Predictive Control of HCCI Combustion Phasing Using Fast Thermal Management and VVA. ***IEEE Transactions on Control Systems Technology***, April 2011. [Number of citations: 12]
28. A. Widd, Hsien-Hsin Liao, J. C. Gerdes, P. Tunestål, R. Johansson, Hybrid Model Predictive Control of Exhaust Recompression HCCI, ***Asian Journal of Control***, Vol. 16, No. 2, 2014, pp. 1–12. [Number of citations: 1]

2. Referee Reviewed Conference Papers

1. A. Björkelund, L. Edström, M. Haage, J. Malec, K. Nilsson, P. Nugues, S. Gestegård Robertz, D. Störkle, A. Blomdell, R. Johansson, M. Linderoth, A. Nilsson, A. Robertsson, A. Stolt, H. Bruyninckx. On the Integration of Skilled Robot Motions for Productivity in Manufacturing, *Proc. IEEE/CIRP International Symposium on Assembly and Manufacturing (ISAM 2011),* May 25-27, 2011, Tampere, Finland. [Number of citations: 15]
2. M. Cescon, I. Dressler, R. Johansson, A. Robertsson. Subspace-based Identification of Compliance Dynamics of Parallel Kinematic Manipulator, *Proc. 2009 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM2009)*, Singapore, July 14-17, 2009, pp. 1028-1032.

3. M. Cescon and R. Johansson, Glycemic Trend Prediction Using Empirical Model Identification, *Proc. Joint 48th IEEE Conference on Decision and Control and 28th Chinese Control Conference (CDC2009 & CCC 2009)*, Shanghai, P.R. China, December 16-18, 2009, pp. 3501-3506. [Number of citations: 11]
4. M. Cescon, R. Johansson, Multi-step-ahead Multivariate Predictors: a Comparative Analysis, *Proc. 49th IEEE Conf. Decision and Control (CDC2010)*, December 15-17, 2010, Atlanta, GA, USA, pp. 2837-2842. [Number of citations: 5]
5. M. Cescon and R. Johansson. On Data-Driven Multistep Linear Predictors, *Preprints of the 18th IFAC World Congress (IFAC2011)*, Milano, Italy, August 28 - September 2, 2011, pp. 11447-11452.
6. M. Cescon, R. Johansson. Patient-specific Glucose Metabolism Models for Model Predictive Control of T1DM Glycemia. *5th International Conference on Advanced Technologies and Treatments for Diabetes (ATTD 2012)*, Barcelona, Spain, 8-11 Feb 2012.
7. M. Cescon, R. Johansson, E. Renard. Personalized short-term blood glucose prediction in T1DM. *5th International Conference on Advanced Technologies and Treatments for Diabetes (ATTD 2012),* Barcelona, Spain, 8-11 Feb 2012.
8. M. Cescon, R. Johansson, E. Renard, J. Place. Modeling the impact of a standardized breakfast on T1DM fasting blood glucose. In *12th Annual Diabetes Technology Meeting (DTM2012)*, Bethesda, MD, USA, Nov 8-10 2012.
9. M. Cescon, M. Stemmann, R. Johansson. Impulsive Predictive Control of T1DM Glycemia: an In-Silico Study. In *Reglermöte 2012*, Uppsala, Sweden, June 13-14, 2012.
10. M. Cescon, M. Stemmann, R. Johansson. Impulsive Predictive Control of T1DM Glycemia: An In-Silico Study. *Proc. ASME 2012 5th Annual Dynamic Systems and Control Conference & JSME 2012 11th Motion and Vibration Conference (DSCC2012-MOVIC 2012)*, Oct 17-19, 2012, Fort Lauderdale, Florida, USA. **Best-Paper-in-Session Award.**
11. M. Cescon, R. Johansson, E. Renard, Low-complexity MISO Models of T1DM Glucose Metabolism, *Proc. 9th Asian Control Conference (ASCC 2013)*, June 23-26, 2013, Istanbul, Turkey.
12. M. Cescon, R. Johansson and E. Renard, Individualized Empirical Models of Carbohydrate and Insulin Effects on T1DM Blood Glucose Dynamics, *Proc. 2013 IEEE Multi-conference on Systems and Control (MSC2013)*, Hyderabad, India, August 28-30, 2013, pp. 258-263.
13. M. Cescon, F. Ståhl, M. Landin-Olsson ,and R. Johansson, Subspace-Based Model Identification of Diabetic Blood Glucose Dynamics, *Proc. 15th IFAC Symposium on System Identification (SYSID2009)*, July 6 - 8, 2009, Saint-Malo, France. [Number of citations: 12]
14. I. Dressler, M. Haage, K. Nilsson, R. Johansson, A. Robertsson and T. Brogårdh, Configuration Support and Kinematics for a Reconfigurable Gantry-Tau Manipulator, *2007 IEEE International Conference on Robotics and Automation (ICRA2007)*, Roma, Italy, April 10-14, 2007, pp.2957-2962.
15. I. Dressler, A. Robertsson and R. Johansson, Automatic Kinematic Calibration of a Modular Gantry-Tau Parallel Robot from a Kinematics Point of View, *2008 IEEE International Conference on Robotics and Automation (ICRA2008)*, Pasadena, CA, USA, May 19-23, 2008, pp. 1282-1287. [Number of citations: 11]
16. M. Haage, I. Dressler, A. Robertsson, K. Nilsson, T. Brogårdh, R. Johansson, Reconfigurable Parallel Kinematic Manipulator for Flexible Manufacturing, *Preprints 13th IFAC Symp. Information Control Problems in Manufacturing (INCOM2013)*, Moscow, Russia, June 3-5, 2009, pp. 145-150. **Best Paper Award.**
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5. Patents

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Five most cited publication [Google Scholar]; >300 publications as of April 2015; **H-index 40;**

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Leonid B. Freidovich's publications

Citation information below is given based on ***Google Scholar*** (on 2015-03-26). However, the numbers of self-citations have been subtracted after manually review of all the listed citing articles.

The list below contains publications only for the last 8 years, i.e. for 2008–2015 with indicated numbers of external citations. The five most cited publications during the whole active research period (1996–2015) are listed at the end.

The five most important publications for the project are marked with **(*)**; *they are:* [J12], [C1], [C8], [C12], *and* [C27].

1. Peer-reviewed original articles (2008-2015)

[J1] S.V. Gusev, L.V. Paramonov, S.S. Pchelkin, A. Robertsson, L.B. Freidovich, and A.S. Shiriaev, "On modification of PD+ controller for orbital stabilization of mechanical systems," *PMM Journal of Applied Mathematics and Mechanics* (Translation of the Russian Journal *Prikladnaya Matematika i Mekhanika*), to appear in 2015.

[J2] D.O. Morales, P.X. La Hera, S. Westerberg, L.B. Freidovich, and A.S. Shiriaev, "Path-constrained motion analysis. An algorithm to understand human performance on hydraulic manipulators," *IEEE Transactions on Human-Machine systems*, vol. 45, no. 2, pp. 187–199, 2015. [http://dx.doi.org/10.1109/THMS.2014.2366873; number of citations: **0**].

[J3] S. Pchelkin, A. Shiriaev, L. Freidovich, U. Mettin, S. Gusev, W. Kwon, and L. Paramonov, "A dynamic human motion: coordination analysis," *Biological Cybernetics*, vol. 109, no. 1, pp. 47–62, 2015. [http://dx.doi.org/10.1007/s00422-014-0624-4; number of citations: **0**].

[J4] A.S. Shiriaev, L.B. Freidovich, and M.W. Spong, "Controlled invariants and trajectory planning for underactuated mechanical systems," *IEEE Transactions on Automatic Control*, vol. 59, no. 9, pp. 2555–2561. [http://dx.doi.org/10.1109/TAC.2014.2308641; number of citations: **0**].

[J5] D.O. Morales, S. Westerberg, P.X. La Hera, U. Mettin, L. Freidovich, and A.S. Shiriaev, "Increasing the level of automation in the forestry logging process with crane trajectory planning and control," to appear in *Journal of Field Robotics*, 2014 [http://dx.doi.org/10.1002/rob.21496; number of citations: **7**].

[J6] A.S. Shiriaev, L.B. Freidovich, and M.W. Spong, A remark on controlled Lagrangian approach," *European Journal of Control*, special issue on "Lagrangian and Hamiltonian Methods for Nonlinear Control", vol. 19, no. 6, pp. 438–444, 2013. [http://dx.doi.org/10.1016/j.ejcon.2013.09.004; number of citations: **1**].

[J7] S.V. Aranovskiy and L.B. Freidovich, "Adaptive compensation of disturbances formed as sums of sinusoidal signals with application to an active vibration control testbench," *European Journal of Control*, special issue on "Benchmark on adaptive regulation: rejection of unknown/time-varying multiple narrow band disturbances", vol. 19, no. 4, pp. 253–265, 2013. [http://dx.doi.org/10.1016/j.ejcon.2013.05.008; number of citations: **4**].

[J8] S.V. Aranovskiy, L.B. Freidovich, L.V. Nikiforova, and A.A. Losenkov, "Modeling and identification of dynamics in a hydraulic actuator with a spool valve. Part I: Modeling / Part II: Identification," Scientific and Technical Journal «Priborostroenie», vol. 56, no. 4, pp. 52–56 / 57–60, 2013 (in Russian). [http://pribor.ifmo.ru/en/article/1270/ / http://pribor.ifmo.ru/en/article/1271/; number of citations: **0**]

[J9] P.X. La Hera, A.S. Shiriaev, L.B. Freidovich, U. Mettin, and S. Gusev, "Stable walking gaits for a three-link planar biped robot with one actuator," *IEEE Transactions on Robotics*, in vol. 29, no. 3, pp. 589–601, 2013. [http://dx.doi.org/10.1109/TRO.2013.2239551; number of citations: **4**].

[J10] L.T. Aguilar, I. Boiko, L. Fridman, and L.B. Freidovich, "Generating oscillations in inertia wheel pendulum via two-relay controller," *International Journal of Robust and Nonlinear Control* , vol. 22, no. 3, pp. 318–330, 2012. [http://dx.doi.org/10.1002/rnc.1696; number of citations: **6**].

[J11] I.M. Meza-Sancheza, L.T. Aguilar, A.S. Shiriaev, L.B. Freidovich, and Y. Orlov, "Periodic motion planning and nonlinear H-infinity tracking control of a 3-DOF underactuated helicopter," *International Journal of Systems Science*, vol. 42, no. 5, pp. 829–838, 2011 (invited paper for the special issue on "New advances in H-infinity control and filtering for nonlinear systems.") [http://dx.doi.org/10.1080/00207721.2010.517874; number of citations: **17**].

[J12] **(*)** A.S. Shiriaev, L.B. Freidovich, R. Johansson, and A. Robertsson, "Global stabilization for a class of coupled nonlinear systems with application to active surge control," *Dynamics of Continuous, Discrete and Impulsive System*, vol. 17 (B), no. 6, pp. 875–908, 2010 (invited paper for the special issue in honor of Professor Hassan K. Khalil's 60th birthday). [http://dcdis001.watam.org/volumes/contents2010/v17n6b.html; number of citations: **6**].

[J13] U. Mettin, P. La Hera, A.S. Shiriaev, and, L.B. Freidovich, "Parallel elastic actuators as a control tool for preplanned trajectories of underactuated mechanical systems," *The International Journal of Robotics Research*, vol. 29, no. 9, pp. 1186–1198, 2010. [http://dx.doi.org/10.1177/0278364909344002; number of citations: **15**].

[J14] A.S. Shiriaev, L.B. Freidovich, and S.V. Gusev, "Transverse linearization for controlled mechanical systems with several passive degrees of freedom," *IEEE Transactions on Automatic Control*, vol. 55, no. 4, pp. 893–906, 2010. [http://dx.doi.org/10.1109/TAC.2010.2042000; number of citations: **46**].

[J15] L.B. Freidovich, A. Robertsson, A.S. Shiriaev, and R. Johansson, "LuGre-model-based friction compensation," *IEEE Transactions on Control Systems Technology*, vol. 18, no. 1, pp. 194–200, 2010. [http://dx.doi.org/10.1109/TCST.2008.2010501; number of citations: **75**].

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[J17] P. La Hera, L.B. Freidovich, A.S. Shiriaev, and U. Mettin, "New approach for swinging up the Furuta pendulum: Theory and experiments," *Mechatronics*, vol. 19, no. 8, pp. 1240–1250, 2009. [http://dx.doi.org/10.1016/j.mechatronics.2009.07.005; number of citations: **17**].

[J18] **(*)** L.B. Freidovich, U. Mettin, A.S. Shiriaev, and M.W. Spong, "A passive 2-DOF walker: Hunting for gaits using virtual holonomic constraints," *IEEE Transactions on Robotics*, vol. 25, no. 5, pp. 1202–1208, 2009. [http://dx.doi.org/10.1109/TRO.2009.2028757; number of citations: **26**].

[J19] L.B. Freidovich, A.S. Shiriaev, F. Gómez-Estern, F. Gordillo, and J. Aracil, "Modification via averaging of partial-energy-shaping control for orbital stabilization: cart-pendulum example," *International Journal of Control*, vol. 82, no. 9, pp. 1582–1590, 2009. [http://dx.doi.org/10.1080/00207170802596272; number of citations: **6**].

[J20] L.B. Freidovich, P. La Hera, U. Mettin, A. Robertsson, A.S. Shiriaev, and R. Johansson, "Shaping stable periodic motions of inertia wheel pendulum: theory and experiment," *Asian Journal of Control*, vol. 11, no. 5, pp. 548–556, 2009. [http://dx.doi.org/10.1002/asjc.135; number of citations: **6**].

[J21] L.B. Freidovich, A.S. Shiriaev, F. Gordillo, F. Gómez-Estern, and J. Aracil, "Partial-energy-shaping control for orbital stabilization of high frequency oscillations of the Furuta pendulum," *IEEE Transactions on Control Systems Technology*, vol. 17, no. 4, pp. 853–858, 2009. [http://dx.doi.org/10.1109/TCST.2008.2005734; number of citations: 0].

[J22] L.B. Freidovich and H.K. Khalil, "Performance recovery of feedback-linearization-based designs," *IEEE Transactions on Automatic Control*, vol. 53, no. 10, pp. 2324–2334, 2008. [http://dx.doi.org/10.1109/TAC.2008.2006821; number of citations: **97**].

[J23] A.S. Shiriaev, L.B. Freidovich, and I.R. Manchester, "Can we make a robot ballerina perform a pirouette? Orbital stabilization of periodic motions of underactuated mechanical systems," *Annual Reviews in Control*, vol. 32, no. 2, pp. 200–211, 2008. [http://dx.doi.org/10.1016/j.arcontrol.2008.07.001; number of citations: **36**].

[J24] U. Mettin, P. La Hera, L.B. Freidovich, and A.S. Shiriaev, "Motion planning for humanoid robots based on the virtual constraints extracted from recorded human movements," *Intelligent Service Robotics*, vol. 1, no. 4, pp. 289–301, 2008. [http://dx.doi.org/10.1007/s11370-008-0027-2; number of citations: **1**].

[J25] L.B. Freidovich, A. Robertsson, A.S. Shiriaev, and R. Johansson, "Periodic motions of the Pendubot via virtual holonomic constraints: Theory and experiments," *Automatica*, vol. 44, no. 3, pp. 785–791, 2008. [http://dx.doi.org/10.1016/j.automatica.2007.07.011; number of citations: **45**].

2. Peer-reviewed conference papers[1] (2008-2015)

[C1] (*) A. Shiriaev, L. Freidovich, A. Robertsson, A. Andersson, and R. Johansson, "IQC arguments for analysis of the 3-state Moore-Greitzer compressor system," to appear in Proc. of the *1st IFAC Conference on Modelling, Identification and Control of Nonlinear Systems*, June 24-26, 2015, Saint-Petersburg, Russia.

[C2] M. Surov, A. Shiriaev, L. Freidovich, S. Gusev, and L. Paramonov, "Case study in non-prehensile manipulation: planning and orbital stabilization of one-directional rollings for the Butterfly robot," to appear in Proc. of the *IEEE International Conference on Robotics and Automation*, May 26-30, 2015, Seattle, Washington, USA.

[C3] C. Vazquez, S. Aranovskiy, L. Freidovich, and L. Fridman, "Second Order Sliding Mode Control of an Industrial Hydraulic System" to appear in Proc. of the *53rd IEEE Conference on Decision and Control*, December 15-17, 2014, Los Angeles, California, USA, pp. 5630–5635. [Number of citations: **0**].

[C4] C. Vazquez, S. Aranovskiy, and L. Freidovich, "Sliding mode control of a forestry-standard mobile hydraulic system" in Proc. of the *13th Variable Structure Systems Workshop*, June 29-July 2, 2014, Nantes, France, 6p. [Number of citations: **2**].

[C5] C. Vazquez, S. Aranovskiy, and L. Freidovich, "Time-varying gain second order sliding mode differentiator," in Proc. of the *19th World Congress of the International Federation of Automatic Control*, August 24-29, 2014, Cape Town, South Africa, pp. 1374–1379. [Number of citations: **2**].

[C6] S. Fodor and L. Freidovich, "Static friction modeling and identification for standard mechatronic systems", in Proc. of the *14th Mechatronics Forum International Conference*, June 16-18, 2014, Karlstad, Sweden, pp. 30–36. [Number of citations: **0**].

[C7] I Yung, S. Aranovskiy, and L. Freidovich, "Case Study on Non-Ideal Current Tracking in Amplifiers for Voltage-Driven Manipulators", in Proc. of the *14th Mechatronics Forum International Conference*, June 16-18, 2014, Karlstad, Sweden, pp. 126–131. [Number of citations: **0**].

[C8] (*) A.A. Rubanova, A. Robertsson, A. Shiriaev, L. Freidovich, and R. Johansson, "Robustness of the Moore-Greitzer compressor model's surge subsystem with new dynamic output feedback controllers," in Prep. of the *19th World Congress of The International Federation of Automatic Control*, Cape Town, South Africa. August 24-29, 2014, pp. 3690–3695. [Number of citations: **0**].

[C9] A.S. Shiriaev, L.B. Freidovich, and M.W. Spong, "Controlled Invariants and Trajectory Planning for Underactuated Mechanical Systems," in Proc. of the *52nd IEEE Conference on Decision and Control*, December 10-13, 2013, Firenze, Italy, pp. 1628–1633. [Number of citations: **0**].

[C10] S. Pchelkin, A.S. Shiriaev, A. Robertsson, and L.B. Freidovich, "Integrated Time-Optimal Trajectory Planning and Control Design for Industrial Robot Manipulator," in Proc. of the *2013 IEEE/RSJ International Conference on Intelligent Robots and Systems*, November 3-8, 2013, Tokyo, Japan, pp. 2521–2526. [Number of citations: **2**].

[1] Extended and modified versions of some of the listed conference contributions are published in peer-reviewed journals. The changes, however, are often significant making these publications complimentary.

[C11] L.T. Aguilar, L. Freidovich, Yu. Orlov, and J.O. Mérida "Performance analysis of relay feedback position regulators for manipulators with Coulomb friction," to appear in Proc. of *European Control Conference*, July 17-19, 2013, Zurich, Switzerland. [Number of citations: **0**].

[C12] **(*)** A.A. Rubanova, A. Robertsson, A. Shiriaev, L. Freidovich, and R. Johansson, "Analytic Parameterization of Stabilizing Controllers for the Surge Subsystem of the Moore-Greitzer Compressor Model," in Proc. of *American Control Conference*, June 17-19, 2013, Washington, DC, USA, pp. 5257–5262. [Number of citations: **0**].

[C13] A.S. Shiriaev, L.B. Freidovich, and M.W. Spong, "A remark on controlled Lagrangian approach for completely integrable mechanical systems," in Proc. of the *4th IFAC Workshop on Lagrangian and Hamiltonian Methods for Non Linear Control*, August 29-31, 2012, Bertinoro, Italy, vol. 4, part 1, pp. 54–59. [Number of citations: **0**].

[C14] L. Freidovich, F. Gordillo, A. Shiriaev, and F. Gomez-Estern, "On generating pre-defined periodic motions in underactuated mechanical systems: the cart-pendulum example," in Proc. of the *IFAC World Congress*, Milano, August 28 – September 2, 2011, pp. 4588–4593. [Number of citations: **0**].

[C15] M. Meza-Sánchez, L.T. Aguilar, A. Shiriaev, L. Freidovich, and Yu. Orlov, "Nonlinear Output Feedback H-infinity-Tracking Control of a 3-DOF Underactuated Helicopter," in Proc. of the *IFAC World Congress*, Milano, August 28 – September 2, 2011, pp. 11145-11150. [Number of citations: **1**].

[C16] S.S. Pchelkin, A.S. Shiriaev, U. Mettin, L.B. Freidovich, T. Aoyama, Z. Lu, and T. Fukuda, "Shaping energetically efficient brachiation motion for a 24-DOF gorilla robot," in Proc. of *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS),* September 25-30, 2011, pp.5094–5099. [Number of citations: **2**].

[C17] D. Ortíz Morales, S. Westerberg, P. La Hera, U. Mettin, L. Freidovich, and A. Shiriaev, "Open-loop control experiments on driver assistance for crane forestry machines," in Proc. of the *International Conference on Robotics and Automation*, Shanghai, China, May 9-13, 2011, pp.1797-1802. [Number of citations: **3**].

[C18] S. Pchelkin, A. Shiriaev, L. Freidovich, U. Mettin, and W. Kwon, "Natural sit-down and chair-rise motions for a humanoid robot," in Proc. of the *49th IEEE Conference on Decision and Control*, December 15-17, 2010, Atlanta, GA, USA, pp. 1136-1141. [Number of citations: **7**].

[C19] D. Ortíz Morales, P. La Hera, U. Mettin, L. Freidovich, A. Shiriaev, S. Westerberg, "Steps in Trajectory Planning and Controller Design for a Hydraulically Driven Crane with Limited Sensing," in Proc. of the *2010 IEEE/RSJ International Conference on Intelligent Robots and Systems*, October 18-22, 2010, Taipei, Taiwan, pp. 3836-3841. [Number of citations: **2**].

[C20] P.X. La Hera, L. Freidovich, A. Shiriaev, and U. Mettin, "Traversing from point-to-point along a straight line with a ballbot," in Proc. of the *8th IFAC Symposium on Nonlinear Control Systems*, September 1-3, 2010, Bologna, Italy. [Number of citations: 0].

[C21] L. Freidovich and A. Shiriaev, "Transverse linearization for an underactuated compass-like biped robot and analysis of the closed-loop system," in Proc. of the *8th*

IFAC Symposium on Nonlinear Control Systems, September 1-3, 2010, Bologna, Italy. [Number of citations: **4**].

[C22] P.X. La Hera, A. Shiriaev, L. Freidovich, and U. Mettin, "Gait Synthesis for a Three-Link Planar Biped Walker with One Actuator," in Proc. of the *IEEE International Conference on Robotics and Automation*, May 3-8, 2010, Anchorage, Alaska, USA, pp. 1715–1720. [Number of citations: **2**].

[C23] U. Mettin, A. Shiriaev, L. Freidovich, and M. Sampei, "Optimal Ball Pitching with an Underactuated Model of a Human Arm," in Proc. of the *IEEE International Conference on Robotics and Automation*, May 3-8, 2010, Anchorage, Alaska, USA, pp. 5009–5014. [Number of citations: **12**].

[C24] L.B. Freidovich, and A. Shiriaev, "Transverse linearization for mechanical systems with passive links, impulse effects, and friction forces," in Proc. of the *48th IEEE Conference on Decision and Control*, December 16-18, 2009, Shanghai, China, pp. 6490–6495; the presentation was nominated (selected into the final list of 5 candidates) for *Guan Zhao-Zhi Award*. [Number of citations: **5**].

[C25] U. Mettin, P.X. La Hera, D.O. Morales, A.S. Shiriaev, L.B. Freidovich, and S. Westerberg, "Trajectory planning and time-independent motion control for a kinematically redundant hydraulic manipulator,'' in Proc. of the *14th International Conference on Advanced Robotics*, June 22-26, 2009, Munich, Germany, pp. 1–6. [Number of citations: **5**].

[C26] S. Westerberg, U. Mettin, A.S. Shiriaev, L.B. Freidovich, and Y. Orlov, "Motion planning and control of a simplified helicopter model based on virtual holonomic constraints,'' in Proc. of the *14th International Conference on Advanced Robotics*, June 22-26, 2009, Munich, Germany, pp. 1–6. [Number of citations: **7**].

[C27] **(*)** A.S. Shiriaev, R. Johansson, A. Robertsson, and L.B. Freidovich, "Criteria for global stability of coupled systems with application to robust output feedback design for active surge control," in Proc. of the *IEEE Multi-conference on Systems and Control*, July 8-10, 2009, St. Petersburg, Russia, pp. 1021–1026. [Number of citations: **2**].

[C28] L.T. Aguilar, I. Boiko, L. Fridman, and L. Freidovich, "Inducing oscillations in an inertia wheel pendulum via two-relays controller: Theory and experiments," in Proc. of the *American Control Conference*, June 10-12, 2009, St. Louis, Missouri, USA, pp. 65–70. [Number of citations: **9**].

[C29] A.S. Shiriaev, L.B. Freidovich, and S.V. Gusev, "Transverse linearization for mechanical systems with several passive degrees of freedom with applications to orbital stabilization," in Proc. of the *American Control Conference*, June 10-12, 2009, St. Louis, Missouri, USA, pp. 3039–3044. [Number of citations: 0].

[C30] P. La Hera, A. Shiriaev, L.B. Freidovich, and U. Mettin, "Orbital stabilization of a pre-planned periodic motion to swing up the Furuta Pendulum: Theory and experiments," in Proc. of the *IEEE International Conference on Robotics and Automation*, May 12-17, 2009, Kobe, Japan, pp. 3562–3567. [Number of citations: **4**].

[C31] U. Mettin, P. La Hera, L.B. Freidovich, and A. Shiriaev, "How springs can help to stabilize motions of underactuated systems with weak actuators," in Proc. of the *47th*

IEEE Conference on Decision and Control, December 9-11, 2008, Cancun, Mexico, pp. 5963–5968. [Number of citations: **2**].

[C32] A. Shiriaev, L.B. Freidovich, and I. Manchester, "Periodic motion planning and analytical computation of transverse linearizations for hybrid mechanical systems," in Proc. of the *47th IEEE Conference on Decision and Control*, December 9-11, 2008, Cancun, Mexico, pp. 4326–4331. [Number of citations: **5**].

[C33] L.B. Freidovich, U. Mettin, A. Shiriaev, and M.W. Spong, "A passive 2DOF walker: Finding gait cycles using virtual holonomic constraints," in Proc. of the *47th IEEE Conference on Decision and Control*, December 9-11, 2008, Cancun, Mexico, pp. 5214–5219. [Number of citations: **2**].

[C34] L.B. Freidovich, A.S. Shiriaev, and I.R. Manchester, "Stability analysis and control design for an underactuated walking robot via computation of a transverse linearization," in Proc. of the *17th IFAC World Congress*, July 6-11, 2008, Seoul, Korea, pp. 10166–10171. [Number of citations: **16**].

[C35] A.S. Shiriaev, R. Johansson, A. Robertsson, and L.B. Freidovich, "Separation principle for a class of nonlinear systems augmented with observers," in Proc. of the *17th IFAC World Congress*, July 6-11, 2008, Seoul, Korea, pp.6196–6201. [Number of citations: **4**].

3. Monographs - none

4. Research review articles - none

5. Books and book chapters (2008-2015)

[B1] L.B. Freidovich, *Control Methods for Robotic Applications. Lecture notes*, 213 pages, National Research University of Information Technologies, Mechanics, and Optics (NRU ITMO), St. Petersburg, Russia, 2013. [http://libris.kb.se/bib/14765489; number of citations: **0**].

[B2] L.B. Freidovich, *Optimal Control for Linear Systems. Lecture notes*, 130 pages, National Research University of Information Technologies, Mechanics, and Optics (NRU ITMO), St. Petersburg, Russia, 2013. [http://libris.kb.se/bib/14765422; number of citations: **1**].

[B3] L.B. Freidovich and A.S. Shiriaev, "Transverse linearization for underactuated nonholonomic mechanical systems with application to orbital stabilization," in *Lecture Notes in Control and Information Sciences* (LCCC Theme Semester), Vol. 417, Distributed Decision Making and Control, R. Johansson and A. Rantzer eds., 2012, Chapter 11, pp. 243–256, Springer, ISBN 978-1-4471-2264-7. [http://dx.doi.org/10.1007/978-1-4471-2265-4_11; number of citations: 0].

6. Patents - none

7. Open-access computer programs or databases - none

7. Popular science articles/presentations (2008-2015)

[P1] "Docent lecture" at TFE, Umeå University, "Control theory: history, state of the art, and challenges," September 2010.

Scientific outcome (1996-2015)

- **35** peer-reviewed journal articles; **58** peer-reviewed international conference contributions; **2** books (lecture notes), and **2** book chapters.
- Google scholar page with complete citation statistics: http://scholar.google.com/citations?user=VBekdAUAAAAJ

The five most cited publications (*1996-2015, according to **Google Scholar** but without counting self-citations*)

- L.B. Freidovich and H.K. Khalil, "Performance recovery of feedback-linearization-based designs," *IEEE Transactions on Automatic Control*, vol. 53, no. 10, pp. 2324–2334, 2008. [Number of citations: **97**].
- L.B. Freidovich, A. Robertsson, A.S. Shiriaev, and R. Johansson, "LuGre-model-based friction compensation," *IEEE Transactions on Control Systems Technology*, vol. 18, no. 1, pp. 194–200, 2010. [Number of citations: **75**].
- A.S. Shiriaev, L.B. Freidovich, and S.V. Gusev, "Transverse linearization for controlled mechanical systems with several passive degrees of freedom," *IEEE Transactions on Automatic Control*, vol. 55, no. 4, pp. 893–906, 2010. [Number of citations: **46**].
- L.B. Freidovich, A. Robertsson, A.S. Shiriaev, and R. Johansson, "Periodic motions of the Pendubot via virtual holonomic constraints: Theory and experiments," *Automatica*, vol. 44, no. 3, pp. 785–791, 2008. [Number of citations: **45**].
- L.B. Freidovich and H.K. Khalil, "Lyapunov-based switching control of nonlinear systems using high-gain observers," *Automatica*, vol. 43, no. 1, pp. 150–157, 2007. [http://dx.doi.org/10.1016/j.automatica.2006.08.010; number of citations: **45**].

CV

Name: Rolf Johansson	**Doctorial degree:** 1983-05-31
Birthdate: 19530817	**Academic title:** Professor
Gender: Male	**Employer:** Lunds universitet

Research education

Dissertation title (swe)
Multivariable Adaptive Control

Dissertation title (en)
Multivariable Adaptive Control

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Subject doctors degree	ISSN/ISBN-number	Date doctoral exam
21199. Övrig annan teknik		1983-05-31

CV

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Gender: Male	**Employer:** Umeå universitet

Research education

Dissertation title (swe)
Logic-Based Switching Control of Nonlinear Systems Using High-Gain Observers

Dissertation title (en)
Logic-Based Switching Control of Nonlinear Systems Using High-Gain Observers

Organisation	Unit	Supervisor
Michigan State University, USA Not Sweden - Higher Education institutes	Department of Mathematics	Hassan K. Khalil

Subject doctors degree	ISSN/ISBN-number	Date doctoral exam
10199. Annan matematik		2005-05-06

Dissertation title (swe)
Stability and Control of Robotic Manipulators

Dissertation title (en)
Stability and Control of Robotic Manipulators

Organisation	Unit	Supervisor
Saint Petersburg State Polytechnical University, Russia Not Sweden - Higher Education institutes	Department of Mechanics and Control Processes	Anatoli A. Pervozvanski

Subject doctors degree	ISSN/ISBN-number	Date doctoral exam
20202. Reglerteknik		1999-06-16

Publications

Name: Rolf Johansson	**Doctorial degree:** 1983-05-31
Birthdate: 19530817	**Academic title:** Professor
Gender: Male	**Employer:** Lunds universitet

Johansson, Rolf has not added any publications to the application.

Publications

Name: Leonid Freidovich	**Doctorial degree:** 1999-06-16
Birthdate: 19730704	**Academic title:** Docent
Gender: Male	**Employer:** Umeå universitet

Freidovich, Leonid has not added any publications to the application.

Register

Terms and conditions

The application must be signed by the applicant as well as the authorised representative of the administrating organisation. The representative is normally the department head of the institution where the research is to be conducted, but may in some instances be e.g. the vice-chancellor. This is specified in the call for proposals.

The signature*from the applicant*confirms that:

- the information in the application is correct and according to the instructions form the Swedish Research Council
- any additional professional activities or commercial ties have been reported to the administrating organisation, and that no conflicts have arisen that would conflict with good research practice
- that the necessary permits and approvals are in place at the start of the project e.g. regarding ethical review.

The signature *from the administrating organisation* confirms that:

- the research, employment and equipment indicated will be accommodated in the institution during the time, and to the extent, described in the application
- the institution approves the cost-estimate in the application
- the research is conducted according to Swedish legislation.

The above-mentioned points must have been discussed between the parties before the representative of the administrating organisation approves and signs the application.

Project out lines are not signed by the administrating organisation. The administrating organisation only sign the application if the project outline is accepted for step two.

Applications with an organisation as applicant is automatically signed when the application is registered.