BIOGRAPHICAL SKETCH

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NAME: Krishnaprasad, P. S.

eRA COMMONS USER NAME

POSITION TITLE: Professor of Electrical and Computer Engineering and Institute for Systems Research

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Start Date MM/YYYY	Completion Date MM/YYYY	FIELD OF STUDY
Indian Institute of Technology, Bombay	B.Tech	08/1967	06/1972	Mechanical Engineering
Syracuse University, Syracuse	M.S.	08/1972	12/1973	Systems and Information Science
Harvard University, Cambridge	Ph.D.	02/1974	06/1977	Engineering

A. Personal Statement

I have held leadership in MURI Centers: (ARO-MURI 1997 on Dynamics and Control of Smart Structures, ONR-MURI 1997 on Auditory and Acoustics Research, ARO-MURI 2001 on Communicating Networked Control Systems, ONR-MURI 2007 on Nonlinear Dynamics in Networked Sensors, ARO-MURI 2013 on Information Engines – Nanoscale Control, Computing, and Information Out of the Equilibrium). I have initiated collaboration with biologists (studying the barn-owl, the FM bat *Eptesicus fuscus,* dragonflies), and analog VLSI specialists, in the integration of auditory signal processing in feedback control (of robots). I have guided undergraduate research: NSF-REU and MERIT/RITE programs in topics including integration of auditory processing and GPS system principles in motion control, studies of collective behavior in robotics, and processing of biological flight data. I have organized: tutorial workshops at American Control Conference (2000, 2015), IEEE Conference on Decision and Control (1998, 2003, 2008, 2014, 2016), and Quantum Control Summer School (2005). I have guided 31 PhD. Students, of whom 10 occupy tenured or tenure-track positions at US universities and abroad, one of whom is a Macarthur Fellow (2004) on the Princeton Faculty.

B. Positions and Honors

Positions and Employment

Assistant Professor of Systems Engineering, Case Western Reserve University, 1977 – 1980
Assistant Professor of Electrical Engineering, University of Maryland, 1980 – 1982
Associate Professor of Electrical Engineering, University of Maryland, 1982 – 1987
Professor of Electrical & Computer Engineering, University of Maryland, 1987 –
Joint appointment: Institute for Systems Research, University of Maryland, 1988 –
(Permanent 1995 –)
Director: Intelligent Servosystems Laboratory, University of Maryland, 1986 – present
Thrust Leader: Center for Auditory and Acoustic Research (MURI), 1997 – 2002
Co-Director: Center for Dynamics and Control of Smart Structures (MURI), 1997 – 2003
Co-Director: Center for Communicating Networked Control Systems (MURI), 2001 – 2007
Co-PI: Information Engines – Nanoscale Control, Computing, & Communication Out of Equilibrium (MURI), 2013 – 2019
Visiting appointment: Erasmus University, Rotterdam, The Netherlands, May-June 1981
Short term visiting appointment: University of California, Berkeley, February 1984
Short term visiting appointment: University of California, Berkeley, February 1985

Short term visiting appointment: University of California, Berkeley,
April 16 - 22 and October 29 - November 6, 1986
Visiting appointment: University of Groningen, The Netherlands, August 1989
Visiting appointment: Cornell University, fall 1989
Visiting Professor: Princeton University, spring 1995
Short term visitor: California Institute of Technology, April 2003
(Also other periods from 1992 onwards)
Short term Visiting Professor: EPFL, Lausanne, Switzerland, July 2004

Honors & Awards

Elected Fellow IEEE (in 1990, *for contributions to Nonlinear and Geometric Control and Engineering Education*);

Outstanding Systems Engineering Faculty (1990 – 1991 & 2008 – 2009), and
Distinguished Faculty Research Fellow (1998 – 2000), University of Maryland;

Member of team recognized by American Helicopter Society's
Grover E. Bell Award (2002) (*for work on smart structures during 1991 – 1996*)
To Alfred Gessow Rotorcraft Research Center

Munich Mathematical Colloquium Lecturer – lecture delivered on "Geometric Control, Cohesion and Pursuit" (October 24, 2006)

Hendrik W. Bode Lecture Prize for 2007 from IEEE Control Systems Society (*for fundamental contributions to the theory of control of natural and synthetic physical systems*) – lecture delivered on "Pursuit and Cohesion: in Nature and by Design" (December 14, 2007)
http://www.ieeecss.org/awards/hendrik-w-bode-lecture-prize

Baetjer Colloquium Lectureship for 2012 from the Mechanical and Aerospace Engineering Department of Princeton University, *in recognition of contributions to the field of geometric control, filtering theory, robotics & bio-inspired design* - lecture delivered on "Structure and Dynamics in Collectives" (April 20, 2012)
http://www.princeton.edu/mae/events/baetjer/

C. Contributions to Science and Engineering

I have contributed to a wide range of subjects. These include:

Geometric control theory and filtering theory; control of infinite dimensional systems; system identification and model reduction; geometric mechanics; dynamics of nonholonomic systems with symmetries; dynamical systems on Lie groups and optimal trajectory generation

Control problems arising in complex multi-body systems (e.g. spacecraft with deformable elastic attachments and fluid filled containers, underwater vehicles)

Problems of modeling, design, motion planning and control, arising in mobile robotics and robotic manipulation; sensors and actuators for robotic end-effectors; motion control for nonholonomic robots; under-actuated autonomous robotic vehicles; GPS-aided navigation of mobile robots

Time-frequency methods for the analysis of signals and systems (e.g. wavelet basis representations); exploitation of auditory-physiological insights in time-frequency analysis of acoustic data; independent component analysis;

Intelligent control architectures for complex systems inspired in part by biological paradigms such as central pattern generators, and space maps associated to auditory and other sensory modalities; learning binaurally directed movement; sensorimotor feedback in echo-locating bats; hybrid models for networks of sensors and actuators; languages for motion control

Technology of smart materials such as piezo-electric and magnetostrictive materials for use in actuation and sensing; nonlinear problems in such materials; hysteresis modeling and compensation; integration of such materials in structures (e.g. networking); computational methods in ferromagnetism with applications to the design of Terfenol-D actuators

Intelligent processing of materials with a special focus on semiconductor manufacturing; modeling, simulation, monitoring and control in semiconductor manufacturing processes, such as rapid thermal chemical vapor deposition; epitaxial growth of thin films and surface reconstruction in epitaxy

Dynamics and control of formations, swarming, flocking and related biological phenomena; acoustics and biological signal processing; pursuit phenomena and prey capture behavior in nature; evolutionary game-theoretic basis for strategies of pursuit; analysis of field data on starling flocks; inverse problem of reconstructing interaction laws for collectives; *cognitive cost* of flocking as measured by generative models from data; continuum models of flocks

Subriemannian geometry and optimal control in the study of collectives, and for the design of efficient, nanoscale heat engines; critical dynamics in field theory and related optimal control problems

The research interests described above are supported by a program of experimental investigations in the **Intelligent Servosystems Lab** (ISL) where, in the period 1986 – 2020, the projects included; experiments in positioning, vibration suppression and impact control of a flexible arm with embedded actuators; mechanical manipulation with a modular hand invented in ISL; a hybrid (piezoelectric-magnetostrictive) motor invented in ISL; nonholonomic robot design; a parallel linkage manipulator invented in ISL; 3-D solid modeling and graphical animation; and motor networks. The **primary current emphasis** in ISL is on mobile robotics and software for control of collectives of robots. A Vicon motion capture system was installed in 2013 to study collective behavior of robots, and is used to validate principles and algorithms applicable to biological and robotic collectives

D. Additional Information: Research Support, Representative Scholarly Work

Over a period of 40 years at the University of Maryland, I have received support for my work from a variety of sources including Department of Defense MURI and regular grants, NIH-NSF CRCNS, National Science Foundation, Department of Energy, and industry.

Some key publications emerging from my work are:

(i) A. M. Bloch, P. S. Krishnaprasad, J. E. Marsden and T. S. Ratiu, “The Euler-Poincaré Equations and Double Bracket Dissipation,” *Communications in Mathematical Physics*, vol. 175, 1-42, (1996).
(ii) E. W. Justh and P. S. Krishnaprasad, “Pattern-Forming Systems for the Control of Large Arrays of Actuators,” *Journal of Nonlinear Science*, Vol. 11, 239-277, (2001) http://dx.doi.org/10.1007/s00332-001-0392-x
(iii) E. W. Justh and P. S. Krishnaprasad, “Equilibria and Steering Laws for Planar Formations,” *Systems and Control Letters*, **52**(1), 25-38, (2004) http://dx.doi.org/10.1016/j.sysconle.2003.10.004
(iv) E. W. Justh and P. S. Krishnaprasad, “Steering Laws for Motion Camouflage,” *Proceedings of the Royal Society of London A*, **462**, 3629-3643, (2006) http://dx.doi.org/10.1098/rspa.2006.1742
(v) E. Wei, E. W. Justh and P. S. Krishnaprasad, “Pursuit and an Evolutionary Game,” *Proceedings of the Royal Society of London A*, **465**, 1539-1559, (2009) http://dx.doi.org/10.1098/rspa.2008.0480

Other significant publications:

(i) A. M. Bloch, P. S. Krishnaprasad, J. E. Marsden and R. M. Murray, “Nonholonomic Mechanics and Symmetry,” *Archive for Rational Mechanics and Analysis,* **136**, 21-99, (1997).
(ii) V. Manikonda and P. S. Krishnaprasad, “Controllability of a Class of Under-actuated

Mechanical Systems with Symmetry," *Automatica*, **38**(11), 1837-1850, (2002) http://dx.doi.org/10.1016/S0005-1098(02)00095-X
(iii) P. S. Krishnaprasad and D. P. Tsakiris, "Oscillations, SE(2)-snakes and Motion Control: A Study of the Roller Racer," *Dynamical Systems,* **16**(4), 347-397, (2001) http://dx.doi.org/10.1080/14689360110090424
(iv) B. Azimi-Sadjadi and P. S. Krishnaprasad, "Approximate Nonlinear Filtering and its Applications in Navigation," *Automatica*, **41**(6), 945-956, (2005) http://dx.doi.org/10.1016/j.automatica.2004.12.013
(v) K. S. Galloway, E. W. Justh and P. S. Krishnaprasad, "Symmetry and reduction in collectives: cyclic pursuit strategies" *Proceedings of the Royal Society of London A*, **469**, 20130264, online 21 August 2013, 24 pages + 12 pages supplement, (2013) http://dx.doi.org/10.1098/rspa.2013.0264