Vijay Kumar

UPS Foundation Professor
Departments of Mechanical Engineering and Applied Mechanics and
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Member of the GRASP Laboratory
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Education

B. Tech., Mechanical Engineering
Indian Institute of Technology, Kanpur, India, May 1983

M.Sc., Mechanical Engineering
The Ohio State University, Columbus, Ohio, March 1985

Ph.D., Mechanical Engineering
The Ohio State University, Columbus, Ohio, September 1987

Professional Experience

2012- Assistant Director, Robotics and Cyber Physical Systems, Office of Science and Technology Policy, Executive Office of the President, Washington DC.

2008-12 Deputy Dean (Education), School of Engineering and Applied Science, University of Pennsylvania.

2005-08 Chairman, Department of Mechanical Engineering and Applied Mechanics, University of Pennsylvania.

2000-04 Deputy Dean (Research), School of Engineering and Applied Science, University of Pennsylvania.

1999 Visiting Professor, Johns Hopkins University, Baltimore, Maryland.

1998- Professor, Department of Mechanical Engineering and Applied Mechanics, University of Pennsylvania (secondary appointment in Computer and Information Science and the Department of Systems Engineering).

1998-05 Director, General Robotics Automation Sensing and Perception (GRASP) Laboratory.

1996 Visiting Scientist, Applied Science and Engineering Laboratories, Alfred I. DuPont Institute, Wilmington, Delaware.

1993-98 Associate Professor, Department of Mechanical Engineering and Applied Mechanics, University of Pennsylvania (secondary appointment in Computer and Information Science).

1987-93 Assistant Professor, Department of Mechanical Engineering and Applied Mechanics, University of Pennsylvania (with a secondary appointment in Computer and Information Science).

1983-87 Research Assistant and Research Fellow, The Ohio State University

Awards/Honors

- The Ohio State University Presidential Fellowship (1986)
- NSF Presidential Young Investigator Award (1991)
- Lindback Award for Distinguished Teaching, University of Pennsylvania (1996)
- The Ferdinand Freudenstein Award for significant contributions to mechanisms and robotics, 5th National Conference on Mechanisms and Robotics (1997)
- Best paper award, Distributed Autonomous Robotic Systems (DARS), 2002.
- Fellow, American Society of Mechanical Engineers (2003)
- Kayamori Best Paper Award, IEEE Int. Conference on Robotics and Automation, 2005.
- IEEE Robotics and Automation Society Distinguished Lecturer (2005-09)
- Fellow, Institute for Electrical and Electronics Engineers (2005)
- Advisor to Best Student Paper Award, IEEE Int. Conference on Robotics and Automation, 2008.
- MSC Software Best Paper Award, ASME Int. Design Engineering Tech. Conferences, 2008.
- Advisor to Best Paper Award, Robotics Science and Systems, 2009.
- Association for Laboratory Automation Award, IEEE Int. Conference on Automation Science and Engineering, 2009.
- Advisor to Best Student Paper Award, Distributed Autonomous Robotic Systems, 2010.
- Best Paper Award, IEEE Int. Conference on Robotics and Automation, 2011.
- Best Paper Award, Robotics Science and Systems, 2011.
- Distinguished Service Award, IEEE Robotics and Automation Society Award, 2012.
- Mechanisms and Robotics Award, ASME Design Engineering Division, 2012.
- The Ohio State University Distinguished Alumnus Award, October 2012.
- World Technology Network Award, October 2012.
- George H. Heilmeier Faculty Award for Excellence in Research, University of Pennsylvania, 2013.
- Member, National Academy of Engineering, 2013.
- Best Paper Award, Robotics Science and Systems, 2013.

Refereed Journal Publications

1. Kumar, R. V., Waldron, K.J. and Tsai, M.J., "Geometric Optimization of Serial Chain Manipulator Structures for Working Volume and Dexterity," *International Journal of Robotics Research*, Vol. 5, No. 2., 1986, pp. 91-103.

2. Pandy, M.G., Kumar, V., Berme, N., and Waldron, K.J., "The Dynamics of Quadrupedal Locomotion," *Journal of Biomechanical Engineering*, Vol. 110, No. 3, 1988, pp. 230-237.

3. Kumar, V. and Waldron, K.J., "Force Distribution in Closed Kinematic Chains," *IEEE Journal on Robotics and Automation*," Vol. 4, No. 6, December 1988, pp. 657-664.

4. Kumar, V. and Waldron, K.J., "Adaptive Gait Control for a Walking Robot," *Journal of Robotic Systems*, Vol. 6, No. 1. February 1989, pp. 49-75.

5. Kumar, V. and Waldron, K.J., "Actively Coordinated Mobility Systems," *ASME Journal of Mechanisms, Transmissions and Automation in Design*, Vol. 111, No. 2, 1989, pp. 223-231.

6. Kumar, V. and Waldron, K.J., "Suboptimal Algorithms for Force Distribution in Multifingered Grippers," *IEEE Journal on Robotics and Automation*, Vol. 5, No. 4, 1989, pp. 491-498.

7. Kumar, V. and Waldron, K.J., "Force Distribution in Walking Vehicles on Uneven Terrain," *ASME Journal of Mechanisms, Transmissions and Automation in Design*, Vol. 112, No. 1, 1990, pp. 90-99.

8. Kumar, V. and Gardner, J.F., "Kinematics of Redundantly Actuated Kinematic Chains," *IEEE Journal on Robotics and Automation*, Vol. 6, No. 13, 1990, pp. 269-273.

9. Kumar, V., "Instantaneous Kinematics of Parallel-Chain Robotic Mechanisms," *ASME Journal of Mechanisms, Transmissions, Automation in Design*, Vol. 114, No. 3, 1992, pp. 349-358.

10. Kim, J-H. and Kumar, V., "Robot Kinematics *via* Line Transformations," *Journal of Robotic Systems*, Vol. 7, No. 4, August 1990, pp. 649-674.

11. Yun, X. and Kumar, V., "An Approach to Simultaneous Control of Trajectory and Interaction Forces in Dual Arm Configurations," *IEEE Journal of Robotics and Automation*, Vol. 7, No. 5, October 1991, pp. 618-625.

12. Kumar, V., "Characterization of Workspaces of Parallel Manipulators," *ASME Journal of Mechanical Design*, Vol. 114, No. 3, 1992, pp. 368-375.

13. Kumar, V., "A Compact Inverse Velocity Solution for Redundant Robots," *Int. Journal of Robotics Research,* Vol. 12, No.1, February 1993, pp. 45-54.

14. Wang, Y. and Kumar, V. , "Simulation of Mechanical Systems with Unilateral Constraints," *Journal of Mechanical Design*, June, 1994, pp. 571-580.

15. Ouerfelli, M. and Kumar, V., "Optimization of a 5-R Linkage,"*ASME Journal of Mechanical Design*, Vol. 116, No. 1, March 1994, pp. 166-173.

16. Sarkar, N., Yun, X. and Kumar, V., "Control of Mechanical Systems with Rolling Contacts: Applications to Mobile Robots," *International Journal of Robotics Research*, Vol. 13, No. 1, February 1994: 55-69.

17. Pfreundschuh, G., Kumar, V. and Sugar, T.G., "Design and Control of a Three Degree of Freedom In-Parallel Actuated Manipulator," *Journal of Robotic Systems*, Vol. 11, No. 2, 1994, pp. 103-115.

18. Paljug, E., Yun, X., and Kumar, V., "Control of Rolling Contacts in Two-Arm Manipulation," *IEEE Transactions on Robotics and Automation*," *IEEE Journal of Robotics and Automation*, Vol. 10, No. 4, August 1994, pp. 441-452.

19. Chen, W. and Kumar, V., Workspaces of Mechanical Systems with Rolling Contacts, *Journal of Advanced Robotics*, The International Journal of the Robotics Society of Japan, Vol. 9, No. 5, 1995: 483-504.

20. Wang, C. C., and Kumar, V., "Kinematics and Control of Mobile Manipulators," *Journal of Applied Mechanisms and Robotics*, 1995, pp. 1-9.

21. Wellman, P., Krovi, V., Kumar, V. and Harwin, W. "A Wheelchair with Legs for People with Motor Disabilities," *IEEE Transactions on Rehabilitation Engineering*, Vol. 3, No. 4, 1995, pp. 343 - 53.

22. Kumar, V., Bajcsy, R., Harwin, W. and Harker, P., "Rapid Design and Prototyping of Customized Rehabilitation Aids," Special Section on Computers in Manufacturing, *Communications of the ACM*, Vol. 39, No. 2., February, 1996: 55-61.

23. Howard, W. S. and Kumar, V., "On the Stability of Grasped Objects[1]," *IEEE Transactions on Robotics and Automation*, Vo. 12, No. 6, December 1996: 904-917.

24. Sarkar, N., Yun, X. and Kumar, V., "Control of Contact Interactions with Acatastatic Nonholonomic Constraints," *International Journal of Robotics Research*, Vol 16, No.3, June l997: 357-374.

25. Garvin, G. J., Zefran, M., Henis, E. A., and Kumar, V. "Two Arm Trajectory Planning in a Manipulation Task," *Journal of Biological Cybernetics*, Vol. 76, 1997: 53-62.

26. Sarkar, N. and Kumar, V., "Velocity and Acceleration Analysis of Contact between Three-Dimensional Rigid Bodies," *ASME Journal of Applied Mechanics*, Vol. 63, Dec. 1996: 974-984.

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[1]This paper was one of five nominations for the best paper award for the *IEEE Transactions on Robotics and Automation* in 1996.

27. Adams, J., *et al*. "Cooperative Material Handling by Human and Robotic Agents: Module Development and System Synthesis," *Expert Systems with Applications*, Pergamon, Vol. 11, No. 2, 1996: 89-97.

28. Sarkar, N., Yun, X. and Kumar, V., "Dynamic Control of 3-D Rolling Contacts in Two-Arm Manipulation," *IEEE Transactions on Robotics and Automation*, Vol. 13, No. 3, pp. 364-376, 1997.

29. Howard, W. S., Zefran, M., and Kumar, V., "On the 6×6 Stiffness Matrix for Three-Dimensional Motions," *Journal of Mechanism and Machine Theory*, Vol. 33, No. 4, May 1998: 389-408.

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31. Zefran, M., Kumar, V. and Croke, C., "Generation of Smooth Three-Dimensional Rigid Body Motions," *IEEE Transactions on Robotics and Automation*, Vol. 14, No. 4, Aug 1998: 576-589.

32. Zefran, M., Kumar, V. and Croke, C., "Metrics and Connections for Rigid Body Kinematics," *International Journal of Robotics Research*, Vol. 18, No. 2, February 1999: 243-258.

33. Chen, C., and Kumar, V., "Motion Planning for Walking Vehicles Using Ordinal Optimization," *IEEE Robotics and Automation Magazine*, Vol. 5, No. 2, June 1998: 22-32.

34. Desai, J., Zefran, M., and Kumar, V., "Two Arm Manipulation with Friction-Assisted Grasping," *International Journal of Advanced Robotics*, Special Issue on "Selected Papers from IROS97".

35. Krovi, V., and Kumar, V., "Design and Control of a Hybrid Mobility System," *ASME Trans. Journal of Mechanical Design*, Vol. 121, No. 3, pp. 448-455, September 1999.

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45. Ouerfelli, M., Kumar, V., and Harwin, W.S. "Methods for kinematic modeling of biological and robotic systems," *Medical Engineering and Physics*, Elsevier Press, Vol. 22, 2000: 509-520.

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73. J.M. Esposito, and V. Kumar, "Event detection near singularities," *ACM Transactions on Modeling and Computer Simulation,* Volume 17, Issue 1, p. 1-22, January 2007.

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75. A. Halasz, V. Kumar, M. Imielinski, C. Belta, O. Sokolsky, S. Pathak and H. Rubin, "Analysis of Lactose Metabolism in *E.coli* using Reachability Analysis of Hybrid Systems," *IET Systems Biology*, Vol. 1, No. 2, 2007: 61-148.

76. M. A. Hsieh, A. Cowley, V. Kumar, and C.J. Taylor. "Maintaining Network Connectivity and Performance in Robot Teams," *Journal of Field Robotics*, Vol. 25, No. 1-2, 2008: 111-131.

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Books

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236. A. A. Julius, M. S. Sakar, E. Steager, U. K. Cheang, M. J. Kim, V. Kumar and G. Pappas, Harnessing Bacterial Power in Microscale Actuation, *Proceedings of the IEEE International Conference on Robotics and Automation* (ICRA), Kobe, Japan, May 13-15, 2009.

237. L. Matthey, S. Berman, and V. Kumar, Stochastic Policies for a Swarm Robotic Assembly System, *Proceedings of the IEEE International Conference on Robotics and Automation* (ICRA), Kobe, Japan, May 13-15, 2009.

238. D. Mellinger, V. Kumar and M. Yim, Control of Locomotion using Shape Changing Wheels, *Proceedings of the IEEE International Conference on Robotics and Automation* (ICRA), Kobe, Japan, May 13-15, 2009.

[13] Best student paper award, IEEE International Conference on Robotics and Automation, 2008.
[14] Finalist, best student paper award, Robotics Science and Systems, 2008.

239. N. Michael, J. Fink, and V. Kumar. Cooperative manipulation and transportation with aerial robots. In Robotics: Science and Systems, Seattle, WA, June 2009[15].

240. D. Cappelleri, A. Halasz, J-Y. Sul, T. Kim, J. Eberwine, and V. Kumar, Towards Fully Automated Phototransfection," *IEEE Conference on Automation Science and Engineering (CASE)*, Bangalore, India, August 22-25, 2009[16].

241. N. Ayanian, V. Kumar and D. Koditschek, Synthesis of Controllers to Create, Maintain and Reconfigure Robot Formations with Communication Constraints, *International Symposium on Robotics Research*, Lucerne, Switzerland, August 31-September 3, 2009.

242. J. Fink, N. Michael, S. Kim and V. Kumar. Planning and control for cooperative manipulation and transportation with aerial robots. *International Symposium on Robotics Research*, Lucerne, Switzerland, August 31-September 3, 2009.

243. J. Fink, N. Michael, A. Kushleyev and V. Kumar. Experimental Characterization of Radio Signal Propagation in Indoor Environments with Application to Estimation and Control. *Proceedings of the International Conference on Intelligent Robots and Systems*, October 2009, St. Louis, Missouri.

244. S. Berman, Q. Lindsey, M. S. Sakar, V. Kumar and S. Pratt, "Study of group food retrieval by ants as a model of multi-robot collective transport strategies," *Robotics Science and Systems*, June, 2010.

245. S. Bhattacharya, V. Kumar and M. Likhachev, "Search-based Path Planning with Homotopy Class Constraints," 3rd International Symposium on Combinatorial Search (SoCS-2010), July 8-10, Stone Mountain Resort, Atlanta, Georgia.

246. S. Bhattacharya, M. Likhachev and V. Kumar, "Multi-agent Path Planning with Multiple Tasks and Distance Constraints," *Proceedings of the IEEE International Conference on Robotics and Automation* (ICRA), Anchorage, AK, May 3-7, 2010.

247. N. Ayanian and V. Kumar, "Abstractions and Controllers for Groups of Robots in Environments with Obstacles," *Proceedings of the IEEE International Conference on Robotics and Automation* (ICRA), Anchorage, AK, May 3-7, 2010.

248. D. Melinger and V. Kumar, "Control and Planning for Vehicles with Uncertainty in Dynamics," *Proceedings of the IEEE International Conference on Robotics and Automation* (ICRA), Anchorage, AK, May 3-7, 2010.

249. J. Fink and V. Kumar, "Online Methods for Radio Signal Mapping with Mobile Robots," *Proceedings of the IEEE International Conference on Robotics and Automation* (ICRA), Anchorage, AK, May 3-7, 2010.

250. M. S. Sakar, E. Steager, A. A. Julius, M. Kim, V. Kumar, and G. J. Pappas, "Biosensing and Actuation for Microbiorobots," *Proceedings of the IEEE International Conference on Robotics and Automation* (ICRA), Anchorage, AK, May 3-7, 2010.

251. J. Derenick, V. Kumar, and A. Jadbabaie, "Towards Simplicial Coverage Repair for Mobile Robot Teams," *Proceedings of the IEEE International Conference on Robotics and Automation* (ICRA), Anchorage, AK, May 3-7, 2010.

252. S. Gray, J. Seo, P. White, N. Zeichner, M. Yim and V. Kumar, "A Toolchain for the Design and Simulation of Foldable Programmable Matter," *Proceedings of the ASME International Design Technical Conferences and Computer and Information in Engineering Conference*, Montreal, Canada, Aug. 15-18, 2010.

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[15] Best student paper award, Robotics Science and Systems, 2009.
[16] Winner of the Association for Laboratory Automation (ALA) Young Scientist award for the best paper and presentation in laboratory automation by a junior faculty member or graduate student.

253. Jiang, Q. and Kumar, V., "The Inverse Kinematics of 3-D Towing," Advances in Robot Kinematics, Ed. Lenarcic, J., Stanisic, M.M., Springer, 2010, pp. 321-328.

254. S. Bhattacharya, V. Kumar and M. Likhachev, "Search-Based Path Planning with Homotopy Class Constraints," Proceedings of the 24th AAAI Conference on Artificial Intelligence (AAAI), July 2010.

255. Jiang, Q. and Kumar, V., "The Direct Kinematics of Objects Suspended from Cables," Proceedings of the ASME IDETC/CIE Mechanisms and Robotics Conference, Montreal, CA, August 15-18, 2010.

256. D. Mellinger, M. Shomin, N. Michael and V. Kumar, " Cooperative Grasping and Transport using Multiple Quadrotors," *10th International Symposium on Distributed Autonomous Robots*, Lausanne, Switzerland, Nov 1-3, 2010.

257. S. Bhattacharya, N. Michael and V. Kumar, "Distributed Coverage and Exploration in Unknown Non-Convex Environments," *10th International Symposium on Distributed Autonomous Robots*, Lausanne, Switzerland, Nov 1-3, 2010.

258. D. Mellinger, N. Michael and V. Kumar, "Trajectory Generation and Control for Precise Aggressive Maneuvers with Quadrotors," *International Symposium on Experimental Robotics*, New Delhi, India, Dec 18-21, 2010.

259. N. Michael, M. Schwager, V. Kumar and D. Rus, "An Experimental Study of Time Scales and Stability in Networked Multi-Robot Systems," *International Symposium on Experimental Robotics*, New Delhi, India, Dec 18-21, 2010.

260. S. Shen, N. Michael and V. Kumar, "3D Estimation and Control for Autonomous Flight with Constrained Computation," *Proc. IEEE International Conference on Robotics and Automation*. Shanghai, China, May, 2011.

261. D. Mellinger and V. Kumar, "Minimum Snap Trajectory Generation and Control for Quadrotors," *Proc. IEEE International Conference on Robotics and Automation*. Shanghai, China, May, 2011.

262. S. Bhattacharya, H. Heidarsson, G. Sukhatme and V. Kumar, "Cooperative Control of Autonomous Surface Vehicles for Oil Skimming and Cleanup," *Proc. IEEE International Conference on Robotics and Automation*. Shanghai, China, May, 2011.

263. M. Sakar, E. Steager, A. Cowley, V. Kumar, and G. Pappas "Wireless Manipulation of Single Cells using Magnetic Microtransporters," *Proc. IEEE International Conference on Robotics and Automation*. Shanghai, China, May, 2011.

264. S. Berman, V. Kumar and R. Nagpal, "Design of Control Policies for Spatially Inhomogeneous Robot Swarms with Application to Commercial Pollination," *Proc. IEEE International Conference on Robotics and Automation*. Shanghai, China, May, 2011.

265. M. Schwager, N. Michael, V. Kumar and D. Rus, "Time Scales and Stability in Networked Multi-Robot Systems," *Proc. IEEE International Conference on Robotics and Automation*. Shanghai, China, May, 2011.

266. Q. Lindsey, D. Mellinger and V. Kumar, "Construction of Cubic Structures with Quadrotor Teams," *Robotics Science and Systems*, Los Angeles, CA, June 27-July 1, 2011.

267. S. Bhattacharya, M. Likhachev and V. Kumar, "Identifying Homotopy Classes of Trajectories for Robot Exploration and Path Planning," *Robotics Science and Systems*, Los Angeles, CA, June 27-July 1, 2011.

268. M. Turpin, N. Michael, and V. Kumar. Trajectory design and control for aggressive formation flight with quadrotors. In Proceedings of the International Symposium on Robotics Research, Flagstaff, AZ, Aug. 2011.

269. M. Schwager, P. Dames, V. Kumar and D. Rus. A Multi-Robot Control Policy for Information Gathering in the Presence of Unknown Hazards," In Proceedings of the International Symposium on Robotics Research, Flagstaff, AZ, Aug. 2011.

270. V. Kumar and N. Michael. Opportunities and Challenges for Micro Aerial Vehicles. In Proceedings of the International Symposium on Robotics Research, Flagstaff, AZ, Aug. 2011.

271. J. Derenick, N. Michael, and V. Kumar. Energy-aware coverage control with docking for networked robots. In Proc. of the IEEE/RSJ Intl. Conf. on Intelligent Robots and Syst., San Francisco, CA, Sept. 2011.

272. D. Mellinger, M. Shomin, Q. Lindsey and V. Kumar. Design, Modeling, Estimation and Control for Aerial Grasping and Manipulation. IEEE/RSJ Intl. Conf. on Intelligent Robots and Syst., San Francisco, CA, Sept. 2011.

273. J. Fink, J. Derenick, and V. Kumar. Localization Using Ambiguous Bearing Estimates from Received Signal Strength. In Proc. of the IEEE/RSJ Intl. Conf. on Intelligent Robots and Syst., San Francisco, CA, Sept. 2011.

274. N. Ayanian, V. Kallem, and V. Kumar. Synthesis of Multiple Feedback Controllers for Multiple Aerial Robots with Geometric Constraints. In Proc. of the IEEE/RSJ Intl. Conf. on Intelligent Robots and Syst., San Francisco, CA, Sept. 2011.

275. D. Mellinger, A. Kushleyev, and V. Kumar. Mixed-Integer Quadratic Program (MIQP) Trajectory Generation for Heterogeneous Quadrotor Teams. Proc. of the IEEE Int. Conference on Robotics and Automation, Minneapolis, MN, May 14-18, 2012.

276. M. Turpin, N. Michael and V. Kumar. Decentralized Formation Control with Variable Shapes for Aerial Robots. Proc. of the IEEE Int. Conference on Robotics and Automation, Minneapolis, MN, May 14-18, 2012.

277. S. Shen, N. Michael and V. Kumar. Autonomous Indoor 3-D Exploration with a Micro-Aerial Vehicle. Proc. of the IEEE Int. Conference on Robotics and Automation, Minneapolis, MN, May 14-18, 2012.

278. D. Wong, E.B. Steager, and V. Kumar, "Near-wall dynamics and photoresponse of swimming microbiorobots," 2012 ASME International Design Engineering Technical Conference, Chicago, IL, 2012.

279. J. Seo, S. Kim and V. Kumar. Planar, Bimanual, Whole-Arm Grasping. Proc. of the IEEE Int. Conference on Robotics and Automation, Minneapolis, MN, May 14-18, 2012.

280. D. Panagou and V. Kumar. Maintaining Visibility for Leader-Follower Formations. Proc. of the IEEE Int. Conference on Robotics and Automation, Minneapolis, MN, May 14-18, 2012.

281. C. Powers, D. Mellinger, A. Kushleyev, B. Kothmann, and V. Kumar. Influence of Aerodynamics and Proximity Effects in Quadrotor Flight. *Int. Symposium on Experimental Robotics*, Quebec, Canada, June 2012.

282. B. Charrow, N. Michael, and V. Kumar. Cooperative multi-robot estimation and control for radio source localization. *Int. Symposium on Experimental Robotics*, Quebec, Canada, June 2012.

283. Subhrajit Bhattacharya, Robert Ghrist and Vijay Kumar Multi-Robot Coverage and Exploration in Non-Euclidean Metric Spaces. In Proceedings of The Tenth International Workshop on the Algorithmic Foundations of Robotics. 13-15 June, 2012.

284. Matthew Turpin, Nathan Michael and Vijay Kumar, Trajectory planning and assignment in multirobot systems, International Workshop on the Algorithmic Foundations of Robotics (WAFR) Boston, MA. June 13 - 15, 2012

285. Subhrajit Bhattacharya, Maxim Likhachev and Vijay Kumar, Search-based Path Planning with Homotopy Class Constraints in 3D. In Invited paper for sub-area spotlights track on 'Best-paper talks', Proceedings of Twenty-Sixth Conference on Artificial Intelligence (AAAI-12). 22-26 July 2012.

286. Alex Kushleyev, Daniel Mellinger, and Vijay Kumar. Towards A Swarm of Agile Micro Quadrotors. Robotics: Science and Systems, July 2012.

287. Soonkyum Kim, Koushil Sreenath, Subhrajit Bhattacharya, and Vijay Kumar, "Trajectory planning for systems with homotopy class constraints", In Latest Advances in Robot Kinematics (ARK), pages 83–90, Innsbruck, Austria, June 2012.

288. Seo, Jungwon, and Vijay Kumar. "Spatial, bimanual, whole-arm grasping."Intelligent Robots and Systems (IROS), 2012 IEEE/RSJ International Conference on. IEEE, October, 2012.

289. Philip Dames, Mac Schwager, Vijay Kumar, and Daniela Rus. “A Decentralized Control Policy for Adaptive Information Gathering in Hazardous Environments.” IEEE Conf. on Decision and Control (CDC), 2012.

290. Soonkyum Kim, Koushil Sreenath, Subhrajit Bhattacharya, and Vijay Kumar, "Optimal trajectory generation under homology class constraints", In IEEE Conference on Decision and Control (CDC), December 2012.

291. Koushil Sreenath, Connie R. Hill, and Vijay Kumar, "A partially observable hybrid system model for bipedal locomotion for adapting to terrain variations", In Hybrid Systems: Computation and Control (HSCC), Philadelphia, April 2013.

292. Philip Dames and Vijay Kumar. “Cooperative Multi-Target Localization with Noisy Sensors,” IEEE Int. Conf. on Robotics and Automation (ICRA), Karlsruhe, Germany, May 2013.

293. S. Gray, S. Chitta, V. Kumar, and M. Likhachev, “A single planner for a composite task of approaching, opening, and navigating through non- spring and spring-loaded doors,” in International Conference on Robotics and Automation, Karlsruhe, Germany, May 2013.

294. M. Pivtoraiko, D. Mellinger, and V. Kumar, “Quadrotor maneuver generation using motion primitives,” in Proceedings of the IEEE International Conference on Robotics and Automation, Karlsruhe, Germany, May 2013.

295. Koushil Sreenath, Nathan Michael, and Vijay Kumar, "Trajectory generation and control of a quadrotor with a cable-suspended load – a differentially-flat hybrid system", In IEEE International Conference on Robotics and Automation, Karlsruhe, Germany, May 2013.

296. E.B. Steager, B. Zern, M.S. Sakar, V. Muzykantov, V. Kumar, “Assessment of protein binding with magnetic microrobots in fluid”, 2013 IEEE International Conference on Robotics and Automation, Karlsruhe, Germany, 2013.

297. Justin Thomas, Joe Polin, Koushil Sreenath, and Vijay Kumar, "Avian-inspired grasping for quadrotor micro UAVs", In ASME International Design Engineering Technical Conference (IDETC), Portland, Oregon, August 2013.

298. Koushil Sreenath and Vijay Kumar, "Dynamics, Control and Planning for Cooperative Manipulation of Payloads Suspended by Cables from Multiple Quadrotor Robots", In Robotics: Science and Systems (RSS), June 2013.

299. Shaojie Shen, Yash Mulgaonkar, Nathan Michael and Vijay Kumar, "Vision-Based State Estimation and Trajectory Control Towards Aggressive Flight with a Quadrotor," Robotics: Science and Systems (RSS), June 2013.

300. Matthew Turpin, Kartik Mohta, Nathan Michael and Vijay Kumar, "Goal Assignment and Trajectory Planning for Large Teams of Aerial Robots," Robotics: Science and Systems (RSS), June 2013.

301. Benjamin Charrow, Nathan Michael and Vijay Kumar, "Approximate Representations for Multi-Robot Control Policies that Maximize Mutual Information," Robotics: Science and Systems (RSS), June 2013.

302. Soonkyum Kim, Subhrajit Bhattacharya, Hordur Heidarsson, Gaurav Sukhatme and Vijay Kumar, "A Topological Approach to Using Cables to Separate and Manipulate Sets of Objects," Robotics: Science and Systems (RSS), June 2013.

Keynote Lectures and Seminars

1. School of Engineering, *Dartmouth College*, Hanover, New Hampshire, February, 1987.

2. Department of Mechanical Engineering, *University of Pittsburgh*, Pittsburgh, February, 1987.

3. Department of Mechanical Engineering and Applied Mechanics, University of Pennsylvania, March 1987.

4. Department of Mechanical Engineering, *University of Michigan*, Ann Arbor, April, 1987.

5. Department of Mechanical Engineering, *University of California*, Irvine, November, 1990.

6. Department of Mechanical Engineering, *University of Duisburg*, Duisburg, Germany, December 1990.

7. Department of Mechanical Engineering, *Darmstadt Technische Hochschule*, Darmstadt, Germany, December 1990.

8. Department of Mechanical Engineering, *University of Stuttgart*, Stuttgart, Germany, December 1990.

9. Department of Mechanical Engineering, *Pennsylvania State University*, State College, February 1991.

10. Department of Mechanical Engineering, *Villanova University*, Villanova, March 1991.

11. *Oakridge National Laboratory*, Oakridge, Tennessee, August 1991.

12. Department of Mechanical Engineering, *John Hopkins University*, December 1992.

13. *Applied Science and Engineering Laboratories*, University of Delaware, April 1993.

14. Department of Mechanical Engineering, University of Maryland, December 1993.

15. Department of Mechanical Engineering, University of Toronto, August 1994.
16. Department of Mechanical Engineering, *John Hopkins University*, November 1994.
17. State University of New York, Stonybrook, March, 1996.
18. Department of Physical Therapy, *University of Delaware*, February 1996.
19. Department of Mechanical Engineering, *University of Delaware*, October 1996.
20. Department of Mechanical Engineering, *Katholik University*, December 1996.
21. Division of Applied Science, *Harvard University*, January 1997.
22. Department of Computer Science, *Federal University of Minas Gerais*, Belo Horizonte, Brazil, June 1997.
23. Department of Mechanical Engineering, *Drexel University*, Philadelphia, February 1998.
24. Department of Mathematics, *University of Pennsylvania*, Philadelphia, November 1998.
25. Department of Mechanical Engineering, *Rutgers Univeristy*, New Jersey, March 1999.
26. Department of Mechanical Engineering, *Arizona State University*, Tempe, Arizona, October 1999.
27. Department of Mechanical Engineering, *Johns Hopkins University*, Baltimore, Maryland, November 1999.
28. Keynote Lecture, National Conference on Mechanisms and Machines, Bombay, India, 1999.
29. *NSF CISE Distinguished Lecture*, Arlington, VA, June 13, 2000.
30. Department of Mechanical Engineering, McGill University, Montreal, Canada, November, 2000.
31. Robotics Institute Seminar, Carnegie Mellon University, February, 2001.
32. Department of Computer Science, Yale University, February 8, 2002.
33. Department of Mechanical Engineering, Drexel University, October 4, 2002.
34. Workshop on Intelligent Human Augmentation and Virtual Environments, University of North Carolina, Chapel Hill, October 17-19, 2002.
35. Intel Corporation, Portland, Oregon, January 2003.
36. Department of Mechanical Engineering, Johns Hopkins University, Baltimore, January 2003.
37. Institute for Systems Research, University of Maryland, February 2003.
38. Coordinated Science Laboratory, University of Illinois, Urbana-Champaign, March 2003.
39. Department of Mechanical Engineering, Tokyo Institute of Technology, Japan, July, 2003.
40. Department of Mechanical Engineering, Boston University, January , 2004.
41. Department of Computer Science, University of Southern California, February, 2004.

42. Jet Propulsion Laboratory, Los Angeles, February, 2004.

43. Engineering in Medicine, National Academy of Engineering Mid-Atlantic Symposium, 2004.

44. Thomas Jefferson University, December, 2004.

45. Air Force Research Laboratory, Space Vehicles Directorate, Kirtland Airforce Base, Albuquerque, New Mexico, May, 2005

46. Department of Mechanical Engineering, University of New Mexico, Albuquerque, May 2005.

47. Public lecture, NASA, Goddard, July 2005.

48. Department of Electrical and Computer Engineering, University of Toronto, September 2005.

49. Robotics Institute, Carnegie Mellon University, February, 2006.

50. Keynote, International Advanced Robotics Program Planning Forum, Orlando, Florida, May 14, 2006.

51. Department of Mechanical Engineering, State University of New York, Buffalo, August 2006.

52. Keynote lecture, 28th International Congress of Electronics Engineers, Institute of Technology, Chihuahua, Mexico, October 2006.

53. Robotics and Intelligent Machines Seminar Series, Georgia Institute of Technology, November 2006.

54. U.S. Military Academy, West Point, February, 2007

55. City College of New York, February, 2007.

56. Keynote Lecture, Foundations of Nanoscale Science: Self-Assembled Architectures and Devices, March, 2007.

57. Department of Mechanical Science and Engineering, University of Illinois, Urbana Champaign, April 2007.

58. Department of Mechanical Engineering, Massachusetts Institute of Technology, May 2007.

59. Keynote Lecture, International Symposium on Assembly and Manufacturing, Ann Arbor, Michigan, July 2007.

60. Ecole Polytechnique Federale de Lausanne, Lausanne, Switzerland, September 2007.

61. Department of Computer Science, Robotics Day, Rennselaer Polytechnic Institute, October 2007.

62. Department of Computer Science, University of Southern California, December 2007.

63. Department of Mechanical Engineering, Nanyang Technological University (NTU), Singapore, December 2007.

64. Department of Electrical Engineering, Polytechnic University, New York, January 2008.

65. Department of Mechanical Engineering, University of California, Santa Barbara, March 2008.

66. Plenary Lecture, IEEE Conference on Automation Science and Engineering, Washington DC, August 2008.

67. Controls Seminar, University of Michigan, Ann Arbor, September 2008.

68. Workshop on Cyber-Physical Systems, International Conference on Robots and Systems (IROS 2008), Nice, France, 2008.

69. Invited Speaker, Robotics and Automation Symposium, University of Tokyo, 2008.

70. Department of Mechanical and Aerospace Engineering, Princeton University, Princeton, February 2009.

71. Keynote Lecture, International Conference on Robot Communication and Coordination, *Robocomm* 2009, Odense, Denmark, April 2009.

72. Department of Mechanical Engineering, Rice University, Houston, April 2009.

73. Distinguished Lecture, IEEE Washington Chapter, McLean, VA, April 2009.

74. Intelligent Systems Division, Manufacturing Engineering Laboratory, National Institute of Standards and Technology, Gaithersburg, MD, April 2009.

75. Booze Allen Hamilton Distinguished Lecturer, Department of Electrical and Computer Engineering, University of Maryland, September 25, 2009.

76. Department of Mechanical Engineering, Carnegie Mellon University, Pittsburgh, October 30, 2010.

77. Center for Information and Systems Engineering, Boston University, January 2010.

78. Keynote, Mechanisms and Robotics, ASME International Design Engineering Technical Conferences, Montreal, Canada, August 16, 2010.

79. Institute of Pure and Applied Mathematics, University of California, Los Angeles, October 18, 2010.

80. Science and Technology Innovators Lecture, University of Minnesota, Minneapolis, November 9, 2010.

81. Department of Mechanical Engineering, Shanghai Jiaotong University, Shanghai, China, December 14, 2010.

82. Department of Mechanical Engineering, Indian Institute of Technology, New Delhi, December 22, 2010.

83. Department of Electrical Engineering and Computer Science, University of California, Berkeley, February 11, 2011.

84. Institute of Systems Research, University of Maryland, College Park, MD, February 25, 2011.

85. Institute for System Research, Instituto Superior Tecnico, Lisbon, Portugal, April 7, 2011.

86. Department of Mechanical Engineering and Applied Mechanics, University of Texas, Austin, April 12, 2011.

87. Keynote, Austrian Robotics Workshop, Tirol, Austria, May 23, 2011.

88. Keynote, Congreso Internacional De Ingenieria Electrica, Electronica, Sistemas Y Ramas Afines, Lima, Peru, August 8, 2011.

89. Plenary, Frontiers of Real-World Multi-Robot Systems: Challenges and Opportunities, Duke University, Durham, NC, October 10, 2011.

90. Department of Mechanical Engineering, Yale University, Nov. 2, 2011.

91. TCS Excellence in Computer Science (TECS) Week, Pune, Jan 9-13, 2012.

92. International Conference on Unmanned Autonomous Vehicles (ICUAV), Bangalore, Feb 24, 2012.

93. 2012 TED (Technology Entertainment and Design) Talk, Long Beach, CA, Feb 29, 2012.

94. Department of Electrical and Computer Engineering, University of Florida, March 15, 2012.

95. Department of Mechanical Engineering, University of South Florida, March 16, 2012.

96. Department of Mechanical Engineering, University of Delaware, April 20, 2012.

97. Northwestern Institute of Complex Systems, Northwestern University, April 25, 2012.

98. Keynote, Field and Service Robotics, Matsushita, Japan, July 17, 2012.

99. Keynote, Global Conference on Educational Robotics, Honolulu, Hawaii, July 20, 2012.

100. Keynote, International Conference on Swarm Intelligence, Brussels, September 13, 2012.

101. Banquet Speaker, 2012 Institute for Translational Medicine and Therapeutics Symposium on Systems Pharmacology and Translational Medicine, October 16, 2012.

102. Keynote Speaker, AAAI Symposium on Human Control of Bio-Inspired Swarms, November 2, 2012.

103. Department of Mechanical Engineering, Purdue University, November 15, 2012.

104. Department of Electrical Engineering and Computer Science, University of California, Berkeley, November 29, 2012.

105. Keynote Speaker, IEEE International Conference on Robotics and Biomimetics (ROBIO 2012), December 12, 2012.

106. TEDx Singapore, Singapore, December 10, 2012.

107. Department of Mechanical Engineering, Seoul National University, December 14, 2012.

108. Rajiv Gandhi Institute for Contemporary Studies, December 17, 2012.

109. TEDx CIA, Washington DC, January 16, 2013.

110. Keynote Speaker, Solid Works World, January 22, 2013.

111. Department of Computer Science, University of Washington, February 19, 2013.

112. Department of Mechanical Engineering, Boston University, March 1, 2013.

113. Department of Computer Science, University of North Carolina, Charlotte, March 21, 2013.

114. Keynote Speaker, United Technologies Fellows Forum, Hartford, April 3, 2013.

115. Robert Chien Distinguished Lecture, Coordinated Sciences Laboratory, University of Illinois, Urbana Champaign, April 9, 2013.

116. Keynote Speaker, Cyber Physical Systems Week, Philadelphia, April 10, 2013.

117. Invited Speaker, Next Generation Robotics, University of Michigan, May 20, 2013.

118. Keynote Speaker, Qualcomm Technical Forum, San Diego, June 5, 2013.

119. Seminar, NEC Laboratories, Princeton, June 13, 2013.

120. Keynote Speaker, 27th Annual Conference on Artificial Intelligence, American Association for Artificial Intelligence, Seattle, July 17, 2013.

121. Invited Speaker, Industrial Design Society of America, Chicago, August 22, 2013.

Invited Presentations in Workshops

1. "Guidance and Coordination in Legged Locomotion Systems," *DARPA Workshop on Advanced Locomotion Systems*, Columbus, Ohio, November 12-13, 1987.

2. "Wrench Decomposition for Multiple Robotic Subsystems," *Applications of Mathematics to Kinematics and Robotics*, Center for Applied Mathematics, Lambrecht, West Germany, June, 1990.

3. "Optimal Solutions for Serial-Chain Inverse Kinematics and for Parallel-Chain Inverse Statics," *Redundancy: Performance Indicies, Singularities Avoidance and Algorithmic Implementations*, IEEE Conference on Robotics and Automation, May 10-15, Nice, France, 1992.

4. "Multiple Mobile Manipulators for Material Handling," *DARPA Workshop on Concurrent Engineering and Manufacturing*, Stanford, CA, June 16-18, 1992.

5. "Rapid Prototyping from Physical Models," *Information Technology for Manufacturing and Concurrent Engineering*, Proceedings of a DARPA Workshop, Stanford, CA, June 16-18, 1992, pp. 721-724.

6. "Simulation of Mechanical Systems with Frictional Contacts," *Applications of Mathematics to Kinematics and Robotics*, Center for Applied Mathematics, Ebernburg, Germany, July 12-17, 1992.

7. Educational Issues in Manufacturing, *Intelligent Systems and Advanced Manufacturing*, SPIE, Philadelphia, PA, October 23-26, 1995 (Panelist on a roundtable).

8. "Motion planning on *SE*(3)," *ARO/Academia/ARL Integration Workshop*, Aberdeen, Sep 11-12, 1995.

9. "Rapid prototyping of rehabilitation aids for people with motor disabilities," *International Symposium on Robotics Research*, Munich, Oct 20-24, 1995.

10. "New Perspectives on Research and Education in Mechanisms," ASME Design Technical Conference - 24 th Biennial Mechanisms conference, Irvine, CA, Aug 20, 1996.

11. A/E/C Systems '97 & M/CAD Expo '97, Philadelphia, June 18, 1997.

12. "Modeling of Frictional Contacts for Dynamic Simulation," Workshop on Dynamic Simulation, *International Conference on Intelligent Robot Systems* (IROS'97), Grenoble, France, Sep 11, 1997.

13. "Analysis of Grasp Stability and Quality Measures," Workshop on Theory of Grasping and Fixturing, *International Conference on Robotics and Automation*, Leuven, Belgium, May 15, 1997.

14. Kumar, V., Zefran, M., and Ostrowski, J., "Motion Planning in Humans and Robots," *Proceedings of the 8th International Symposium on Robotics Research,* Springer Verlag, Kanagawa, Japan, October 3-7, 1997.

15. "Challenges in Simulation of Systems with Multiple Frictional Contacts," Workshop on New Directions in Contact Analysis and Simulation, *International Conference on Robotics and Automation*, May 16, 1998.

16. "Metrics for Robotic Grasping and Fixturing," Workshop on Grasping, Fixturing, and Manipulation: Toward a Common Language, *International Conference on Robotics and Automation*, May 16, 1998.

17. "Screw System Theory and Applications," Tutorial organized with K. J. Waldron, *ASME Design Technical Conference* - 25th Biennial Mechanisms conference, Atlanta, GA, September, 1998.

18. ARO Workshop on Hybrid Systems, July 1998.

19. Networks of Embedded Systems, DARPA NEST Workshop, Boston, March 2000.

20. New directions in dynamics and controls, Chair, NSF Workshop on Mathematics and Robotics, Washington DC, May 2000.

21. Challenges in Robotics, Dynamic Systems and Controls, College Park, MD, June 2000.

22. Next Generation Human-Assist Devices and Automation, NSF/NIOSH Workshop, Sept, 2000. Organized with Steve Derby and Sridhar Kota.

23. Applications of Screw System Theory and Lie Theory to Spatial Kinematics, *ASME Design Technical Conference* - 25th Biennial Mechanisms conference, Baltimore, MD, September, 2000. Organizer.

24. Cooperative Control and Sensing with Multiple Robots, AFOSR Workshop on Cooperative Control, Gainesville, Florida, December, 2000.

25. Hybrid Systems Approach to Biomolecular Networks, DARPA Workshop on Biocomputation, Washington, D.C., March 1, 2001.

26. Cooperative Control of Multiple Robotics, DARPA Workshop on Cooperative Robotics, February 20, 2001.

27. Cooperative Robotics, *Symposium on Control of Groups*, 5th SIAM Conference on Control and its Applications, July 9-13, 2001.

28. Cooperative Control of Aerial and Ground Vehicles, Workshop on Intelligent Human Augmentation and Virtual Environments, University of North Carolina, Chapel Hill, October 17-19, 2002.

29. SIAM Annual Meeting, Snowbird, Utah, May 2003.

30. Multi-robot Grasping, Fixturing and Manipulation, Keynote Address, International Federation for the Theory of Mechanisms and Machines, Tokyo, Japan, July, 2003.

31. ONR GATO Workshop, Washington D.C., February, 2004.

32. AMS meeting, Mathematics in Robotics, Northwestern University, October, 2004.

33. ISAT Study: Embedded Humans, Stanford University, June 29, 2005.

34. Keynote, Aerospace and Guidance Control Meeting, Hilton Head, SC, October 17, 2005.

35. An International Assessment of the State-of-the-Art and Challenges in Robotics, *International Symposium on Robotics Research,* San Fransisco, CA, October 12-15, 2005.

36. IPAM Workshop on Swarming by Nature and by Design, March 1, 2006.

37. Challenges in Networked Robot Systems, Workshop on Network Robot Systems, IEEE International Conference on Robotics and Automation, Orlando, Florida, May 19, 2006.

38. Robotics and Cyber-Physical Systems, Workshop on Cyber Physical Systems, International Conference on Intelligent Robots and Systems (IROS), Nice, France, Sep 24, 2008.

39. Natural Algorithms, Princeton University, November 2010.

40. Opportunities and challenges with autonomous micro aerial vehicles. Proc. of the Intl. Sym. of Robot. Research, Flagstaff, AZ, Aug. 2011.

Patents

Kumar, V., Wellman, P. and Krovi, V., "Adaptive Mobility System," U.S. Patent No. 5,513,716, April 16, 1996.

Daniilidis, K., Angelopoulou, E. and Kumar, V., "Multispectral Omnidirectional Optical Sensor and Methods Therefore," U. S. Patent No. 6,982,743, January 3, 2006.

Membership on Editorial Boards

- Editorial Board, *Journal of the Franklin Institute* (1994 - 2000).
- Associate Editor, *IEEE Transactions on Robotics and Automation* (1994-1998).
- Associate Editor, *ASME Journal of Mechanical Design* (1997- 2001).
- Editorial Board, *Electronic Journal of Computational Kinematics* (2001-2002).
- Editor, *IEEE Transactions on Automation Science and Engineering* (2007-2012)
- Editorial Board, *Springer Tracts on Advanced Robotics* (2009 -)
- Editorial Board, *ASME Journal of Mechanisms and Robotics* (2009-).
- Editorial Board, *Autonomous Robots* (2010 -).

Press Coverage

1. Scientific American, *Free wheeling*, C. Seife, December 1995.
2. Philadelphia Inquirer, *Walking wheelchair*, Leslie Nicholson, February 12, 1998. (Excerpts from this two page feature appeared in newspapers all over the country.)
3. Advance, *Robotic wheelchair*, Jolynn Weiler, March 30, 1998: pages 35-36.
4. Philadelphia Channel 6 TV, Prime Time, 1998. (This five minute segment on robotics research featuring my work ran several times through 1998.)
5. Fox News, Interview, July 25, 1998.
6. Financial Times, Interviewed on robotics exhibits by high school students at the International Science Fair in Philadelphia, May 1999.
7. Prism, American Society of Engineering Educators, feature articles on robotics technology and education, March 2000.
8. Wall Street Journal, features robotics technology for servicing satellites, February 2005.

9. Philadelphia Business Journal, *Robots putting their heads together*, June 10, 2005, http://philadelphia.bizjournals.com/philadelphia/stories/2005/06/13/story1.html. (Also appeared on MSNBC – http://msnbc.msn.com/id/8199356/)
10. Philadelphia Inquirer, September 2006.
11. National Geographic, June 2007. http://www7.nationalgeographic.com/ngm/0707/feature5/.
12. SAAST Robotics for High School Students, Fox TV, Channel 29 and NBC TV, Channel 3, Philadelphia, July 27, 2007. NSF Press release: http://www.nsf.gov/news/news_summ.jsp?cntn_id=110002&org=NSF&from=news.
13. Interview on Aggregation and Swarm Behaviors on the one hour Seattle Public Radio *Weekday* Program, February 9, 2009. http://www.kuow.org/program.php?id=16878.
14. Coverage of work on autonomous aerial robots. New Scientist number 1 video clip of the month, New York Times one of five robots to watch, Popular Science, Engadget, New Yorker
    - http://www.newscientist.com/article/dn19032-new-scientist-tv--best-of-the-web.html
    - http://bits.blogs.nytimes.com/2010/07/15/five-robots-to-watch/?src=me&ref=technology
    - http://www.popsci.com/technology/article/2010-07/video-upenns-quadcopters-now-work-teams-lift-heavy-payloads
    - http://www.popsci.com/technology/article/2010-06/upenns-autonomous-quadcopter-makes-navigating-tight-spaces-look-easy
    - http://www.newyorker.com/reporting/2012/05/14/120514fa_fact_paumgarten
15. Coverage of work on swarms of aerial robots.
    - http://www.cnn.com/2012/03/04/opinion/ted-kumar-flying-robots/index.html
    - http://online.wsj.com/article/SB10001424052970203370604577263320286138892.html
    - http://www.newyorker.com/reporting/2012/05/14/120514fa_fact_paumgarten?currentPage=all
16. PBS Nova, The Rise of the Drones, http://www.pbs.org/wgbh/nova/military/rise-of-the-drones.html
17. Philadelphia Magazine,
    Smartest People in Philadelphia, http://www.phillymag.com/articles/smartest-people-philadelphia/.

Membership on Planning and Review Committees

- Robotics Council, National Science Foundation, 2000-2002.
- Robotics Technical Advisory Board, Army Research Laboratories, 2004.
- NAS Committee on Assessment of Options for Extending the Life of the Hubble Space Telescope (pre-publication copy of report), 2004.
- NSF/NASA Committee on Assessment of International Research and Development in Robotics, 2004.
- National Resource Council Committee to review NASA's Capability Roadmaps on Human Exploration Systems and Mobility and Autonomous Systems and Robotics, 2005.
- NSF Council of Visitors, Computer and Information Science and Engineering, 2006.
- CCC Robotics Roadmap Committee, 2008-09.

Professional Affiliations

1. Fellow, American Society of Mechanical Engineers
2. Fellow, Institution of Electrical and Electronic Engineers
3. Member, American Society of Engineering Education
4. Member, Association for Computing Machinery

Program Committees

- Program Committee, *4th International Conference on Advanced Robotics*, 1988.
- Applied Mechanics Division Committee, American Society of Mechanical Engineers, Philadelphia, 1988 - 1991.
- Program Committee, *5th International Conference on Advanced Robotics*, 1991.
- Program Committee, *International Conference on Intelligent Robot Systems* (IROS'95), Pittsburgh, PA, 1995.

- Program Committee, *Second ECPD International Conference on Advanced Robotics, Intelligent Automation and Active Systems*, Vienna, Austria, 1996.
- Program Committee, *IEEE International Conference on Robotics and Automation*, Leuven, Belgium, 1997.
- Co-organizer of workshop "New Directions in Contact Analysis and Simulation," *International Conference on Robotics and Automation*, May 16, 1998.
- Program Committee, *Mechanisms Conference, ASME Design Technical Conferences*, Atlanta, Sept 13-16, 1998.
- Program Committee, *International Conference on Rehabilitation Robotics*, Stanford, Palo Alto, 1999.
- Program Committee, *International Conference on Robotics and Automation*, Stanford, April 2000.
- ASME Design Engineering Division, Mechanisms Committee, 2000-2006.
- Program Committee*, IEEE/RSJ International Conference on Intelligent Robots and Systems*, Hawaii, October, 2001.
- Program Committee, *ASME Design Engineering Technical Conferences*, Mechanisms Committee, Pittsburgh, September 2001.
- Program Committee, ISORA 2002 9th International Symposium on Robotics and Applications, Orlando, Florida.
- Program Committee, ISRA 2002, 3rd International Symposium on Robotics and Automation, Toluca, Mexico.
- Program Committee, *International Conference on Robotics and Automation*, Washington, D.C., May 2002.
- Program Committee, *International Conference on Robotics and Automation*, Taipei, Taiwan, September 2003.
- Program Committee, *International Conference on Robotics and Automation*, New Orleans, LA, May 2004.
- Program Committee*, IEEE/RSJ International Conference on Intelligent Robots and Systems*, Las Vegas, October, 2003.
- Program Committee*, 7th International Symposium on Distributed Autonomous Robotic Systems*, Toulouse June 23-25, 2004.
- Program Committee*, 5th International Symposium on Intelligent Autonomous Vehicles*, Lisbon, Portugal, July 2-4, 2004.
- Program Committee, *International Conference on Robotics and Automation*, Barcelona, April 2005.
- Program Committee*, IEEE/RSJ International Conference on Intelligent Robots and Systems*, 2005.
- Senior Program Committee, *Robotics: Science and Systems*, Cambridge, June, 2005.
- Program Co-Chair, *IEEE International Conference on Automation Science and Engineering,* Scottsdale, Arizona, 2007.
- Senior Program Committee, *Autonomous Agents and Multi-Agent Systems* (AAMAS), 2008.
- Senior Program Committee, *International Conference on Robotics and Automation*, Pasadena, April 2008.
- Senior Program Committee, *International Conference on Robotics and Automation*, Tokyo, May 2009.
- General Conference Co-Chair, *IEEE International Conference on Automation Science and Engineering,* Bangalore, India 2009
- Program Chair, *International Conference on Robotics and Automation*, Anchorage, May 2010.
- Senior Program Committee, *International Conference on Robotics and Automation*, Shanghai, May 2011.
- Senior Program Committee, *International Conference on Robotics and Automation*, Minneapolis, May 2012.
- Senior Program Committee, *International Conference on Robotics and Automation*, Karlsruhe, May 2013.

Professional Society Committees

- Chair, Mechanisms and Robotics Committee, ASME Design Engineering Division, 2006-2007.
- Administrative Committee Elected Member, IEEE Robotics and Automation Society, 2007-2009.
- Associate Vice President, Administrative Committee, IEEE Robotics and Automation Society, 2008-2009.

- Administrative Committee Member at Large, IEEE Robotics and Automation Society, 2010-12.
- Member, Design Engineering Division Executive Committee, ASME, 2008-present.

Organization of Conferences and Workshops

- Conference Chair, *27th Biennial Conference on Mechanisms and Robotics*, *ASME Design Engineering Technical Conferences*, Mechanisms Committee, Montreal, September 2002.
- *Block Island Workshop on Cooperative Control*, Organizer (with N. Leonard and S. Morse), Block Island, June 10-12, 2003.
- *Robotics and Emergency Response*, Organizer (with D. Rus and S. Singh), *IEEE/RSJ International Conference on Intelligent Robots and Systems* (IROS) Workshop, October 26, 2003.
- *Workshop on Swarming in Natural and Engineered Systems*, NAPA, CA, August 2-3, 2005.
- General Conference Chair, *ASME Design Engineering Technical Conferences*, Philadelphia, September 2006.
- Conference Co-Chair, *International Symposium on Experimental Robotics*, Rio de Janeiro, Brazil, July 2006.
- Local Arrangements Co-Chair, *Robotics Science and Systems*, Philadelphia, PA, August 13-15, 2006.
- *2nd Biennial Workshop on Swarming in Natural and Engineered Systems*, Philadelphia, PA, May 16-17, 2007.
- Conference Co-Chair, *International Symposium on Experimental Robotics*, Athens, Greece, July 2008.
- *3rd Biennial Workshop on Swarming in Natural and Engineered Systems*, Block Island, RI, June 3-4, 2009.
- Program Chair, *IEEE International Conference on Robotics and Automation,* Anchorage, Alaska, 2010.
- Conference Co-Chair, *International Symposium on Experimental Robotics*, New Delhi, India, December 2010.
- Conference Co-Chair, *International Symposium on Experimental Robotics*, Quebec City, Canada, June 2012.

Supervision of Doctoral Dissertations

1. Nathan Ulrich, Mechanical Design Optimization of Manipulator Design Performance, Fall 1990. Currently, Reseach Scientist, Woods Hole Oceanographic Laboratory, Massachussetts.
2. Jung-ha Kim, Kinematics and Statics of Multifingered Grippers, Fall 1990. Currently Professor, Kook Min University, Seoul, N. Korea.
3. Yin-Tien Wang, Analysis and Simulation of Mechanical Systems with Multiple Frictional Contacts, Summer 1992. Currently, Associate Professor, Tamkang University, Taiwan.
4. Nilanjan Sarkar, Control of Mechanical Systems with Rolling Contacts, Spring 1993 (co-supervised by X.Yun). Currently, Associate Professor, Vanderbilt University.
5. Mohamed Ouerfelli, Kinematics of head movements in paraplegics and interaction with robot manipulators, November 1994. Currently, Assistant Professor, King Fahd University, Saudi Arabia.
6. William Howard, Stability of Grasps: Beyond Force Closure, June 1995. Currently, Manager, Kliklok Corporation, Atlanta, Georgia.
7. Chau-Chang Wang, Kinematics and Control of Redundant Nonholonomic Systems, August 1995. Currently, Associate Professor, National Sun Yat-sen University, Taiwan.
8. Milos Zefran, Continuous methods for motion planning, December 1996. Currently, Assistant Professor, University of Illinois, Chicago, Recipient of the NSF Career Award.
9. Jaydev Desai, Motion planning and control of cooperative robotic systems (co-supervised by J. P. Ostrowski). Currently, Associate Professor, University of Maryland.
10. Venkat Krovi, Design and Virtual Prototyping of User Customized Assistive Devices. (co-supervised by G. K. Ananthasuresh). Currently, Assistant Professor, McGill University, Canada.
11. Thomas G. Sugar. Coordination of multiple mobile robots for material handling. Currently, Assistant Professor, Arizona State University, Phoenix, Arizona.
12. Peter Kraus. Modeling of Rigid Body Contacts for Dynamic Simulation.
13. Peng Song. Dynamics, Analysis and Simulation of Multibody Systems with Frictional Contacts. Currently, Assistant Professor, Rutgers University of Pennsylvania.

14. Joel Esposito. Simulation and Control of Hybrid Systems with Applications to Multi-agent Mobile Robotics. Currently, Assistant Professor, U. S. Naval Academy.
15. Aveek Das, Cooperative Control of Robot Formations. 2004. Currently at Sarnoff Corporation.
16. Calin Belta. Geometric Methods for Multirobot Planning and Control. 2003. Currently, Assistant Professor, Drexel University.
17. Rahul Rao, Image Based Control of an Unmanned Ground Vehicle from an Overhead Camera, 2004. Currently at Intel Corporation.
18. Sachin Chitta, Dynamics and Control of Modular Locomotion Systems, 2005. Research Scientist, Willow Garage.
19. Sarangi Patel Parikh, A Framework for Computer Mediated Motion Control: Human Robot Augmentation with Applications to Assistive Technology, 2005. Assistant Professor, U. S. Naval Academy.
20. Meghann Lomas, December 2006. Lockheed Martin Corporation.
21. Mong-Ying (Ani) Hsieh, August 2007. Assistant Professor, Drexel University.
22. David Cappelleri, Flexible Automation for Micro and Meso-Scale Manipulation Tasks with Applications to Manufacturing and Biotechnology, August 2008. Assistant Professor, Purdue University.
23. Nathan Michael, Planning and control for teams of robots in complex environments, December 2008. Research Assistant Professor, Carnegie Mellon University.
24. Ethan Stump, Control for Localization and Visibility Maintenance of an Independent Agent using Robotic Teams, December 2009. Army Research Laboratory.
25. Spring Berman, Abstractions, Analysis Techniques, and Synthesis of Scalable Control Strategies for Robot Swarms, May 2010. Postdoctoral Fellow, Harvard University, Assistant Professor, Arizona State University.
26. Mahmut Selman Sakar, MicroBioRobots for Single Cell Manipulation, September 2010 (co-supervised with G. Pappas). Postdoctoral Fellow, Massachusetts Institute of Technology.
27. Nora Ayanian, August 2011 (co-supervised with D. Koditschek). Assistant Professor, University of Southern California.
28. Jonathan Fink, August 2011. Army Research Laboratory.
29. Subhrajit Bhattacharya, Jan 2012, Postdoctoral Fellow, Department of Mathematics, University of Pennsylvania.
30. Daniel Mellinger, Jan 2012, President, KMel Robotics.
31. Quentin Lindsey, July 2012, Aeroenvironment Inc.
32. Steven Gray, July 2013, Lockheed Martin.
33. Soonkyum Kim, August 2013, Postdoctoral Fellow, Carnegie Mellon University.

Postdoctoral Fellows

1. Elan Henis, 1992-93 (currently at the IBM Haifa Research Laboratory).
2. Herman Bruyninckx, 1996-97 (currently on the faculty of the Katholik University, Leuven, Belgium).
3. Jean-Marc Vezien, 1996-98 (currently at INRIA, France).
4. Greg Grudic, 1998-01 (currently Asst. Prof., Computer Science, Univ. Colorado).
5. Rafael Fierro, 1999 –01 (currently Prof., Electrical Engineering, University of New Mexico).
6. John Ben Southall, 1999- 00 (currently at Sarnoff).
7. Herbert Tanner, 2001-2002 (joint with George Pappas)
8. Xiaoye Wang, 2002 (joint with Harvey Rubin and G. K. Ananthasuresh)
9. Ben Grocholsky, 2003-2006 (Research Scientist, Carnegie Mellon University).
10. Peng Song, 2003-2005 (currently Asst. Prof., Rutgers University).
11. Luiz Chaimowicz, 2003-2005 (currently Asst. Prof., Federal University of Mineas Gerais, Brazil).
12. Peng Cheng, 2005-2008 (currently Research Scientist, Mathworks Inc.).
13. Adam Halasz, 2005-2008 (currently Assistant Professor, West Virginia University).
14. Savvas Loizou, 2005 – 2007 (Asst. Prof., Frederick University, Cyprus).
15. Bogdan Gavrea, 2006 – 2007 (Asst. Prof., Technical University of Cluj-Napoca, Romania).
16. Jason Derenick, 2009- 2011. (United Technologies).
17. Vinutha Kallem, 2008 – 2011. (Sarnoff Corporation).
18. Qimi Jiang , 2009 – 2011. (Mining Technology International, Sudbury, Ontario).
19. Koushil Sreenath, 2012-13. (Asst. Prof., Carnegie Mellong University).

Supervision of Masters Thesis

1. Michael C. Johnson, Force and Motion Control of Redundantly Actuated Robotic Systems with Closed Kinematic Chains, Fall 1989.
2. George Pfreundschuh, Kinematics, Design and Control of a Parallel Manipulator, Summer 1990.
3. Leslie Johnson, A Numerical Technique for Determination of Contact Forces for Multifingered Robotic Grippers, Summer 1991.
4. Thomas G. Sugar, Design and Control of an in-Parallel Pneumatically-Actuated Manipulator, Summer 1992.
5. J. Chris Gerdes, Modeling and Analysis of the Dynamic Behavior of Spur Gears with Applications To Control, Summer 1992.
6. Seshadri Narasimhan, Control of Robot Manipulators in Singular Configurations (May 1994).
7. Greg Garvin, Kinematics and Trajectory Generation in Two-Armed Reaching and Manipulation (May 1994).
8. Parris Wellman, An Adaptive Mobility System, August 1994.
9. Milos Zefran, Numerical Techniques for Time Optimal Robot Control, August 1995.
10. Venkat Krovi, Modeling and Control of a Hybrid Locomotion System, December 1995.
11. Brad Dufour, Strength Amplification in Assistive Devices for People with Physical Disabilities, December 1997.
12. Robert Breslawski, Articulated wheeled and legged mobility system for uneven terrain, December 1999.
13. Dimitris Theodorakatos, Cable-Actuated Parallel Manipulators, May 2007.
14. Erik Smith, Path-planning and control with workspace constraints of cable-actuated parallel manipulators, December 2008.
15. Dinesh Thakur, May 2011.
16. Mike Shomin, July 2011.

Courses taught

Freshman level

Introduction to Design and Manufacturing (MEAM 100)

Sophomore level

Engineering Mechanics - Dynamics (MEAM 211), Mechanical Engineering Laboratory (MEAM 247), EAS 299, Engineering Research Experience (Course on selecting research problems and mentors, and writing research proposals)

Junior level

Kinematics and Dynamics of Machinery (MEAM 452), Senior Design Projects (MEAM 445), EAS 300, Engineering Research and Scholarly Communication (course focusing on preparing papers for publication)

Senior level

Kinematics and Dynamics of Machinery (MEAM 452), Modeling and Control of Mechanical Systems (MEAM 513), Senior Design Projects (MEAM 446), Engineering Mathematics (MEAM 500), Robotics (MEAM 520), Dynamics (MEAM 535), Mechatronics (MEAM 410)

Graduate level - first year (core courses)

Engineering Mathematics (MEAM 500), Modeling and Control of Mechanical Systems (MEAM 513), Robotics (MEAM 520), Dynamics (MEAM 535)

Graduate level - advanced (electives)

Advanced Kinematics (MEAM 528), Advanced Topics in Robotics (CIS 681, MEAM 620), Robot Control (CIS 682), Human Visuo-Motor Control (co-taught, Psych 739).

Current Funding

1. National Science Foundation, ITR Collaborative Research: Networks of Robots and Sensors for First Responders, Principal Investigator at Penn [with D. Rus (MIT) and S. Singh (CMU)], 2004-2008.
2. National Science Foundation, Grasp and Manipulation Planning in the Presence of Dynamics and Uncertainty, Principal Investigator at Penn [with J. C. Trinkle and J-S. Pang (RPI)].

3. Army Research Office, MURI, Scalable Swarms of Autonomous Robots and Mobile Sensors (SWARMS), 2004-2009 (PI, with Berkeley, Santa Barbara, MIT and Yale collaborators)
4. Department of Education, GAANN Fellowships in Biological Modeling, Analysis, Computation and Synthesis, 2006-2009.
5. National Science Foundation, IUCRC Center for First Response, Principal Investigator, 2006-present.
6. Army Research Laboratory, Micro Autonomous Systems Technologies – Autonomy, 2008-2013 [Center Director and PI with Georgia Tech, Berkeley and U. New Mexico].
7. Office of Naval Research, Heterogeneous Unmanned Networked Vehicles, 2008-2013 [with G. Pappas (PI), Ali Jadbabaie, Dan Koditschek, and investigators from Georgia Tech, Arizona State University and Berkeley].
8. Defense Advanced Research Projects Agency, Programmable Matter, 2008-2010 [with M. Yim, and investigators from MIT (prime), Harvard and Berkeley.]
9. Office of Naval Research, Adaptive Networks for Threat and Intrusion Detection and Termination (ANTIDOTE), 2009-2014 [Penn PI, with investigators from USC (prime), CMU and MIT].
10. Office of Naval Research, Smart Adaptive Reliable Teams for Persistent Surveillance (SMARTS), 2009-2014 [Penn PI, with investigators from MIT (prime), Berkeley, and Boston University].
11. Lockheed Martin, Teams of Autonomous Robots and Sensors for ISR, 2009-2010.
12. Army Research Laboratory, Robotics Collaborative Technology Alliance – 2010-15 [with K. Daniilidis (PI), D. Koditschek, M. Yim, K. Kuchenbecker, J. Shi and multiple other institutions.]
13. Defense Advanced Research Projects Agency, ARM-S, 2010-12 [Penn PI, with investigators from iRobot (prime) and U. Massachussetts.]
14. Air Force of Scientific Research, Control of Heterogeneous Assets for Situational Awareness, 2010-15 [with D. Koditschek (PI), A. Jadbabaie, A. Ribeiro and investigators from U. Minnesota and U. California Berkeley].

Previous Funding

1. University of Pennsylvania Research Foundation, *Force and touch sensing in robotics and manufacturing*, $10,000, 1988-1991, Principal Investigator.
2. University of Pennsylvania Research Foundation, *Dynamic coordination for robot manipulators*, $10,000, 1991-1992 (Xiaoping Yun, Vijay Kumar and Sumit Roy), Co-Principal Investigator.
3. NSF, *CISE Research Instrumentation*, $118,000, 1991-1993 (Vijay Kumar, Xiaoping Yun, Sumit Roy and Richard Paul), Principal Investigator.
4. Barrett Technology Incorporated, *Control of enveloping grasps*, $25,000 (1992-1993), Principal Investigator.
5. NATO, *Dynamics of Multi-Body Systems with Multiple Frictional Contacts*, 215,000 Belgian Francs (approximately $20,000), 1992-1994 (Horst Klepp and Vijay Kumar), Co-Principal Investigator.
6. University of Pennsylvania, University Educational Funds, Computer Integrated Manufacturing, $30,000, 1992-93, Principal Investigator.
7. University of Pennsylvania Research Foundation, *Coordination of limbs in biological systems*, $10,000, 1993-94, Principal Investigator.
8. Neymours Foundation, A.I. DuPont Institute, *Design and control of a pneumatic, wheelchair-mounted, robot arm*, $75,000, 1990-1993, Principal Investigator.
9. Whitaker Foundation, *Walking chairs for the disabled*, $180,000, 1992-1995 (Vijay Kumar, Xiaoping Yun and William Harwin), Principal Investigator.
10. Tokheim Corporation, *Automatic Fueling of Vehicles,* $90,000, 1993-95, Principal Investigator.
11. NASA, *Enveloping Grasps with Mobile Whole Arm Manipulators*, $66,000, 1993-1995, Principal Investigator.
12. DARPA, *Multiagent intelligent adaptive coordinated robotic system*, $1,542,367, 1991-1994 (Ruzena Bajcsy, Vijay Kumar, Max Mintz, Richard Paul, and Xiaoping Yun), Co-Principal Investigator.
13. NSF, *Cooperation and Coordination of Two Arms in Biological and Robotic Systems*, $240,000, 1992-1996 (Vijay Kumar and Xiaoping Yun), Principal Investigator.
14. NSF, *Presidential Young Investigator Award*, $327,500 (1991-97), Principal Investigator.
15. NSF, Gateway coalition grant, $272,541, 1993-1998, Principal Investigator.
16. NSF, Acquisition of Equipment for a Customized Production Systems Laboratory, $483,721, 1995-1997 (V. Kumar, P. Harker, M. Cohen, D. Bogen, N. Badler, R. Bajcsy, R. Paul, and J. Smith), Principal Investigator.
17. NSF, *Graduate Traineeship*, $550,000, 1993-1998 (R. Bajcsy, V. Kumar, M. Mintz, R. Paul, G. Provan and S. Roy), Co-Principal Investigator.
18. NSF, Rapid Prototyping of Aids for the Physically Disabled, $1,400,000, 1994-97 (R. Bajcsy, V. Kumar, D. Bogen, W. Harwin and D. Metaxas), Co-Principal Investigator.
19. Defense Advanced Research Projects Agency, Omnidirectional Sensing and Control for Multirobot Coordination, $450,000, 1998-99 (V. Kumar, C. J. Taylor, K. Daniilidis, and J. Ostrowski), Principal Investigator.
20. ARO, Multi-University Research Initiative: Algorithmics of Motion, $2,500,000, 1995-2000 (R. Bajcsy, V. Kumar, E. Simoncelli, M. Mintz, D. Metaxas, J. Gallier), Co-Principal Investigator.
21. ARO, Algorithms for Motion Planning, Sensing and Simulation, $110,000, 1996-1998 (R. Bajcsy, V. Kumar, C.-H. Chen and P. Harker), Co-Principal Investigator.
22. NSF, Asymmetric Broadcast Channels: Applications to Multirobot Coordination, $834,000, 1997-2002 (R. Bajcsy, D. Farber, V. Kumar, I. Lee, and J. Smith), Co-Principal Investigator.
23. NSF, Micro and Macro Prototyping of Compliant Mechanisms, $300,000, 1997-2000 (J. Ostrowski, G. K. Suresh, R. Bajcsy, and V. Kumar), Co-Principal Investigator.
24. Department of Education, Graduate Assistance in Areas of National Need, $500,000, 1998-2001, Principal Investigator.
25. Mellon Foundation, Electronic Enterprise for Cost-Effective Laboratory Instruction, 1997-2000 (D. Pope, V. Kumar, M. Litt, K. Tobin, J. Van der Spiegel), Co-Principal Investigator.
26. Defense Advanced Research Projects Agency, Control of Multiple Autonomous Robots, $1,300,000, 1999-2001 (V. Kumar, R. Alur, I. Lee, C. J. Taylor, K. Daniilidis, J. Ostrowski, and L. Ungar), Principal Investigator.
27. Defense Advanced Research Projects Agency, Design, Implementation, and Validation of Embedded Software, $2,200,000, 2000-2003 (with R. Alur, I. Lee, and G. Pappas), Co-Principal Investigator.

28. National Science Foundation, Customized Interfaces For Assistive Technology, $489,800, 2000-2003 (with C.J. Taylor and J. Ostrowski), Principal Investigator.
29. Air Force Office of Scientific Research, Coordinated Control of Groups of Vehicles, $500,000, 2001-2004 (with J. Ostrowski and N. Leonard), Principal Investigator.
30. Defense Advanced Research Projects Agency, Modeling, Analysis, Simulation and Synthesis of Biomolecular Networks, $1,799,999, 2001-2004 (with H. Rubin), Co- Principal Investigator.
31. National Science Foundation, Modeling and Analysis of Biological Information Networks, $300,000, 2002-2003 (with R. Alur, G. Pappas, and H. Rubin), Co-Principal Investigator.
32. Lockheed Martin, NEPHEST Research, $192,024, 2002-2003 (with R. Alur, G. Pappas, and O. Sokolosky), Principal Investigator.
33. Defense Advanced Research Projects Agency, Adaptive, Autonomous Robot Teams for Situational Awareness, $3,919,191, 2002-2004, (with C.J. Taylor and J. Ostrowski), Principal Investigator.
34. National Science Foundation, ITR: Antidote: Adaptive Network of Robots for Threat and Intrusion Detection and Emergency Response, $300,000, 2002-2005, Principal Investigator.
35. National Science Foundation, Focus Research Collaborative Proposal: Differential Algebraic Inequalities and Their Applications, $210,000, 2002-2005, Principal Investigator.
36. National Science Foundation, NEAR: Network of Autonomous Robots, $453,799, (J. Ostrowski), 2002-2005, (with J. Ostrowski), Principal Investigator.
37. Army Research Office, MURI via U Cal – Berkley, Adaptive Coordinated Control of Intelligent Multi-Agent Teams (ACCLIMATE), $1,406,500, 2002-2007, (with K. Daniilidis,J. Ostrowski, G. Pappas, and C.J. Taylor), Principal Investigator at Penn [with S. S. Sastry (PI) and H. Choset].
38. National Science Foundation, Scalable Algorithms for Safety Verification and Reachability Analysis of Hybrid Systems, Principal Investigator at Penn [with C. Belta, Boston University], $130,000, 2004-2007.
39. Lockheed Martin Corporation, Intelligent Control and Autonomous Replanning of Unmanned Systems (ICARUS), 2006-2007, $317,848.
40. Office of Naval Research, Verification and Validation for Autonomous Systems, $333,900, 2004-2006.
41. Defense Advanced Research Projects Agency, Nano Air Vehicles (with M. Yim, PI), $120,548, 2006-2007.
42. Boeing Company, Research and Simulation Development for "Topology Control Algorithms for Ad Hoc Rotorcraft Teams," 2006-2007.

Industrial Consulting and Research Partnerships

- SRI, 2010-present.
- International Assessment and Strategy Center, 2009-present.
- Lockheed Martin, 2005-present.
- Boeing Company, 2005-2006.
- Honda Motor Company 1999-2005.
- General Motors Corporation, 1999-2000.
- Tokheim Corporation, 1994-1996.
- USPS and Planmatics, 1996.
- Ford Motor Company, 1996.
- Barrett Technology, 1992-1993.