Curriculum Vitae of Dr. Anil V. Rao

Department of Mechanical and Aerospace Engineering
MAE-A 314
University of Florida
Gainesville, FL 32607
Tel: (352) 392-5523 (Office); (352) 672-1529 (Mobile)
E-mail: anilvrao@ufl.edu

EDUCATION

Princeton University — Princeton, NJ
Ph.D., Mechanical and Aerospace Engineering — June 1996

Princeton University — Princeton, NJ
M.A., Mechanical and Aerospace Engineering — June 1992

University of Michigan — Ann Arbor, MI
M.S.E., Aerospace Engineering — December 1989

Cornell University — Ithaca, NY
B.S., Mechanical Engineering (with Distinction); A.B., Mathematics — May 1988

ACADEMIC APPOINTMENTS

University of Florida — Gainesville, FL
Department of Mechanical and Aerospace Engineering
Professor (with Tenure) — August 2019 - Present
Associate Professor (with Tenure) — August 2012 - August 2019
Assistant Professor (Tenure Accruing) — July 2006 - August 2012

Boston University — Boston, MA
Department of Mechanical Engineering
Lecturer/Senior Lecturer — September 2001 - May 2006

INDUSTRY APPOINTMENTS

The Charles Stark Draper Laboratory, Inc — Cambridge, MA
Guidance, Navigation, and Control Systems Division
Senior Member of the Technical Staff — August 2000 - June 2006

The Aerospace Corporation — El Segundo, CA
Flight Mechanics Department
Member and Senior Member of the Technical Staff — March 1996 - August 2000

CITATION STATISTICS

Web of Science Citation Count — 4 January 2021
3294 Total Citations — h-Index = 24
Number of Highly Cited Papers — 2

Google Scholar Citation Count — 2 October 2021
7675 Total Citations — h-Index = 37

JOURNAL PUBLICATIONS

1. Pager, E. R. and **Rao, A. V.**, "Method for Solving Bang-Bang and Singular Optimal Control Problems using Adaptive Radau Collocation," *Computational Optimization and Applications*, Submitted for Publication, September 2021.

2. Miller, A. T. and **Rao, A. V.**, "End-to-End Performance Optimization for High-Speed Ascent-Entry Missions," *Journal of Spacecraft and Rockets*, In Revision, September 2021.

————————————————Above This Line: Manuscripts Under Review————————————————

3. Keil, R. E., Miller, A. T., Kumar, M., and **Rao, A. V.**, "A Warm Start Method for Solving Chance Constrained Optimal Control Problems," *ASME Journal of Dynamic Systems, Measurement, and Control*, Vol. 143, No. 21, December 2021, 9 Pages. https://doi.org/10.1115/1.4052173

4. Holden, B. V., He, S., and **Rao, A. V.**, "Minimum-Time Earth-to-Mars Interplanetary Orbit Transfer Using Adaptive Gaussian Quadrature Collocation," *Journal of Spacecraft and Rockets*, Published Online in Early View, 9 August 2021. https://doi.org/10.2514/1.A35014.

5. Miller, A. T., Hager, W. W., and **Rao, A. V.**, "Mesh Refinement Method for Solving Optimal Control Problems with Nonsmooth Solutions Using Jump Function Approximations," *Optimal Control Applications and Methods*, Vol. 42, No. 4, July–August 2021, pp. 1119–1140. https://doi.org/10.1002/oca.2719

6. Eide, J. D., Hager, W. W., and **Rao, A. V.**, "Modified Legendre-Gauss-Radau Collocation Method for Solving Optimal Control Problems with Nonsmooth Solutions," *Journal of Optimization Theory and Applications*, Published Online in Early View, 27 February 2021. https://doi.org/10.1007/s10957-021-01810-5.

7. Keil, R. E., Miller, A. T., Kumar, M., and **Rao, A. V.**, "Method for Solving Chance Constrained Optimal Control Problems Using Biased Kernel Density Estimators," *Optimal Control Applications and Methods*, Vol. 42, No. 1, January–February 2021, pp. 330-354. https://doi.org/10.1002/oca.2675.

8. Dennis, M. and **Rao, A. V.**, "Optimal Guidance and Control of a Low-Altitude Skid-To-Turn Vehicle," *Journal of Spacecraft and Rockets*, Vol. 58, No. 3, May 2021, pp. 894—905. https://doi.org/10.2514/1.A34844.

9. Dennis, M. and **Rao, A. V.**, "Performance Optimization of a Low-Altitude Skid-To-Turn Vehicle," *Journal of Spacecraft and Rockets*, Vol. 58, No. 3, May 2021, pp. 595–608. https://doi.org/10.2514/1.A34843.

10. Agamawi, Y. M. and **Rao, A. V.**, "CGPOPS: A C++ Software for Solving Multiple-Phase Optimal Control Problems Using Adaptive Gaussian Quadrature Collocation and Sparse Nonlinear Programming,", *ACM Transactions on Mathematical Software*, Vol. 46, No. 3, July 2020, pp. 25:1–25:38. https://doi.org/10.1145/3390463.

11. Agamawi, Y. M. and **Rao, A. V.**, "Comparison of Derivative Estimation Methods in Solving Optimal Control Problems Using Direct Collocation,", *AIAA Journal*, Vol. 58, No. 1, January 2020, pp. 341–354. https://doi.org/10.2514/1.J058514.

12. Hager, W. W., Hou, H., Mohapatra, S., and **Rao, A. V.**, and Wang, X-S, "Convergence Rate for a Radau hp Collocation Method Applied to Constrained Optimal Control," *Computational Optimization and Applications*, Published Online: 2 May 2019. https://doi.org/10.1007/s10589-019-00100-1

13. Dennis, M., Hager, W. W., and **Rao, A. V.**, "Method for Computational Guidance and Control Using Adaptive Gaussian Quadrature Collocation," *Journal of Guidance, Control, and Dynamics*, Vol. 41, No. 9, September 2019, pp. 2026–2040. http://doi.org/10.2514/1.G003943.

14. Liu, F., Hager, W. W., and **Rao, A. V.**, "Adaptive Mesh Refinement Method for Optimal Control Using Decay Rates of Legendre Polynomial Coefficients," *IEEE Transactions on Control Systems Technology*, Vol. 26, No. 4, July 2018, pp. 1475–1483. https://doi.org/10.1109/TCST.2017.2702122.

15. Fuhr, R. And **Rao, A. V.**, "Minimum-Fuel Low-Earth Orbit Aeroglide and Aerothrust Aeroassisted Orbital Transfer Subject to Heating Constraints," *Journal of Spacecraft and Rockets*, Vol. 55, No. 3, May - June 2018. pp. 723–748. http://doi.org/10.2514/1.A34073.

16. Hager, W. W., Liu, J., Mohapatra, S., **Rao, A. V.**, and Wang X-S, "Convergence Rate for a Gauss Collocation Method Applied to Constrained Optimal Control," *SIAM Journal on Control and Optimization*, Vol. 56, No. 2, March–April 2018, pp. 1386–1411. https://doi.org/10.1137/16M1096761.

17. Peloni, A., **Rao, A. V.**, and Ceriotti, M., "Automated Trajectory Optimizer for Solar Sailing (ATOSS)," *Aerospace Science and Technology*, Vol. 72, January 2018. pp. 465–475. http://doi.org/10.1016/j.ast.2017.11.025.

18. Weinstein, M. J. and **Rao, A. V.**, "Algorithm 984: ADiGator, a Toolbox for the Algorithmic Differentiation of Mathematical Functions in MATLAB Using Source Transformation via Operator Overloading," *ACM Transactions on Mathematical Software*, Vol. 44, No. 2, Article 21, September 2017, pp. 21:1–21:25. https://doi.org/10.1145/3104990.

19. Hager, W. W., Hou, H., and **Rao, A. V.**, "Lebesgue Constants Arising in a Class of Collocation Methods," *IMA Journal of Numerical Analysis*, Vol. 37, No. 4, October 2017, pp. 1884–1901. https://doi.org/10.1093/imanum/drw060.

20. Meyer, A. J., Eskinazi, I., Jackson, J. N., **Rao, A. V.**, Patten, C., and Fregly, B. J, " Muscle Synergies Facilitate Computational Prediction of Subject-Specific Walking Motions," *Frontiers in Bioengineering and Biotechnology*, Vol. 4, Article 77, October 2016, 26 pages. https://doi.org/10.3389/fbioe.2016.00077.

21. De Groote, F., Kinney, A. L., **Rao, A. V.**, and Fregly, B. J. "Evaluation of Direct Collocation Optimal Control Problem Formulations for Solving the Muscle Redundancy Problem," *Annals of Biomedical Engineering*, Vol. 44, No. 10, October 2016, pp. 2922–2936. https://doi.org/10.1007/s10439-016-1591-9.

22. Weinstein, M. J. and **Rao, A. V.**, "A Source Transformation via Operator Overloading Method for the Automatic Differentiation of Mathematical Functions in MATLAB," *ACM Transactions on Mathematical Software*, Vol. 42, No. 2, June 2016, pp. 11:1–11:44. https://doi.org/10.1145/2699456.

23. Hager, W. W., Hou, H., and **Rao, A. V.**, "Convergence Rate for a Gauss Collocation Method Applied to Unconstrained Optimal Control," *Journal of Optimization Theory and Applications*," Vol. 169, No. 3, June 2016, pp. 801–824. https://doi.org/10.1007/s10957-016-0929-7.

24. Graham, K. F. and **Rao, A. V.**, "Minimum-Time Trajectory Optimization of Low-Thrust Earth-Orbit Transfers with Eclipsing," *Journal of Spacecraft and Rockets*," Vol. 53, No. 2, March–April 2016, pp. 289–303. https://doi.org/10.2514/1.A33416.

25. Cannataro, B., Davis, T. A., and **Rao, A.. V.**, "State-Defect Constraint Pairing Graph Coarsening Method for Karush-Kuhn-Tucker Matrices Arising in Orthogonal Collocation Methods for Optimal Control Problems," *Computational Optimization and Applications*, Vol. 64, No. 3, July 2016, pp. 793–819. https://doi.org/10.1007/s10589-015-9821-x.

26. Liu, F., Hager, W. W., and **Rao, A. V.**, "Mesh Refinement for Optimal Control Using Nonsmoothness Detection and Mesh Size Reduction," *Journal of the Franklin Institute*, Vol. 352, No. 10, October 2015, pp. 4081–4106. https://doi.org/10.1016/j.jfranklin.2015.05.028.

27. Graham, K. F. and **Rao, A. V.**, "Minimum-Time Trajectory Optimization of Many Revolution Low-Thrust Earth-Orbit Transfers," *Journal of Spacecraft and Rockets*, Vol. 52, No. 3, May–June 2015, pp. 711–727. https://doi.org/10.2514/1.A33187.

28. Limebeer, D. J. N and **Rao, A. V.**, "Faster, Higher, and Greener: Vehicular Optimal Control," *IEEE Control Systems Magazine*, Vol. 35, No. 2, April 2015, pp. 36–56. http://doi.org/10.1109/MCS.2014.2384951.

29. Limebeer, D. J. N., Perantoni, G., and **Rao, A. V.** , "Optimal Control of Fomula One Car Energy Recovery Systems," *International Journal of Control*, Vol. 87, No. 10, October 2014, pp. 2065–2080. https://doi.org/10.1080/00207179.2014.900705.

30. Françolin, C. C. and **Rao, A. V.**, "Costate Estimation in Optimal Control Using a Integral Gaussian Quadrature Orthogonal Collocation Methods," *Optimal Control Applications and Methods*, Vol. 36, No. 4, July - August 2015, pp. 381–397. https://doi.org/10.1002/oca.2112.

31. Patterson, M. A., Hager, W. W., and **Rao, A. V.**, "A ph Mesh Refinement Method for Optimal Control," *Optimal Control Applications and Methods*, Vol. 36, No. 4, July - August 2015, pp. 398–421. https://doi.org/10.1002/oca.2114.

32. Patterson, M. A. and **Rao, A. V.**, "GPOPS-II: A MATLAB Software for Solving Multiple-Phase Optimal Control Problems Using hp-Adaptive Gaussian Quadrature Collocation Methods and Sparse Nonlinear Programming," *ACM Transactions on Mathematical Software*, Vol. 41, No. 1, October–December 2014, pp. 1:1–1:37. https://doi.org/10.1145/2558904.

33. Patterson, M. A., Weinstein, M., and **Rao, A. V.**, "An Efficient Overloaded Method for Computing Analytic Derivatives of Mathematical Functions in MATLAB," *ACM Transactions on Mathematical Software*, Vol. 39, No. 3, April 2013, pp. 17:1–17:36. https://doi.org/10.1145/2450153.2450155.

34. Şenses, B. and **Rao, A. V.**, "Optimal Finite-Thrust Small Spacecraft Aeroassisted Orbital Transfer," *Journal of Guidance, Control, and Dynamics*, Vol. 36, No. 6, November–December 2013, pp. 1802–1810. https://doi.org/10.2514/1.58977.

35. Françolin, C. C., **Rao, A. V.**, Duarte, C., and Martel, G., "Optimal Control of an Autonomous Surface Vehicle to Improve Connectivity in an Underwater Vehicle Network," *Journal of Aerospace Computing, Information, and Communication*, Vol. 9, No. 1, September 2012, pp. 1–13. https://doi.org/10.2514/1.I010002.

36. Patterson, M. A. and **A. V. Rao**, "Exploiting Sparsity in Direct Collocation Pseudospectral Methods for Solving Optimal Control Problems," *Journal of Spacecraft and Rockets*, Vol. 49, No. 2, March–April 2012, pp. 364–377. https://doi.org/10.2514/1.A32071.

37. Darby, C. L., Garg, D., and **Rao, A. V.**, "Costate Estimation Using Multiple-Interval Pseudospectral Methods," *Journal of Spacecraft and Rockets*, Vol. 49, No. 5, September–October 2011, pp. 618–628. https://doi.org/10.2514/1.A32040.

38. Darby, C. L., Hager, W. W., and **Rao, A. V.**, "An hp-Adaptive Pseudospectral Method for Solving Optimal Control Problems," *Optimal Control Applications and Methods*, Vol. 32, No. 4, July–August 2011, pp. 476–502. https://doi.org/10.1002/oca.957.

39. Darby, C. L. and **Rao, A. V.**, "Minimum-Fuel Low-Earth Orbit Aeroassisted Orbital Transfer of Small Spacecraft," *Journal of Spacecraft and Rockets*, Vol. 48, No. 4, July–August 2011, pp. 618-628. https://doi.org/10.2514/1.A32011.

40. Garg, D., Patterson, M. A., Françolin, C., Darby, C. L., Huntington, G. T., Hager, W. W., and **Rao, A. V.**, "Direct Trajectory Optimization of Finite-Horizon and Infinite-Horizon Optimal Control Problems Using a Radau Pseudospectral Method," *Computational Optimization and Applications*, Vol. 49, No. 2, June 2011, pp. 335–358. https://doi.org/10.1007/s10589-009-9291-0.

41. Darby, C. L., Hager, W. W., **Rao, A. V.**, "Direct Trajectory Optimization Using a Variable Low-Order Pseudospectral Method," *Journal of Spacecraft and Rockets*, Vol. 48, No. 3, May–June 2011, pp. 433-445. https://doi.org/10.2514/1.52136.

42. Garg, D., Hager, W. W., and **Rao, A. V.**, "Pseudospectral Methods for Solving Infinite-Horizon Optimal Control Problems," *Automatica*, Vol. 47, No. 4, April 2011, pp. 829–837. https://doi.org/10.1016/j.automatica.2011.01.085.

43. Garg, D., Patterson, M. A., Hager, W. W., **Rao, A. V.**, Benson, D. A., and Huntington, G. T., "A Unified Framework for the Numerical Solution of Optimal Control Problems Using Pseudospectral Methods," *Automatica*, Vol. 46, No. 11, November 2010, pp. 1843–1851. https://doi.org/10.1016/j.automatica.2010.06.048.

44. **Rao, A. V.**, Benson, D. A., Darby, C. L., Patterson, M. A., Françolin, C., Sanders, I., and Huntington, G. T., "Algorithm 902: GPOPS, A MATLAB Software for Solving Multiple-Phase Optimal Control Problems Using Gauss Pseudospectral Method," *ACM Transactions on Mathematical Software*, Vol. 37, No. 2, April–June 2010, pp. 22:1–22:39. https://doi.org/10.1145/1731022.1731032.

45. Baumgartner, K. A. C., Ferrari, S., and **Rao, A. V.**, "Optimal Control of an Underwater Sensor Network for Cooperative Target Tracking," *IEEE Journal of Oceanic Engineering*, Vol. 34, No. 4, October 2009, pp. 678–697. https://doi.org/10.1109/JOE.2009.2025643.

46. Matsumura, T., Gogu, C., Haftka, R., and **A. V. Rao**, "Aeroassisted Orbital Transfer Considering Thermal Protection System Mass," *Journal of Guidance, Control, and Dynamics*, Vol. 32, No. 3, May–June 2009, pp. 927–938. https://doi.org/10.2514/1.37684.

47. Huntington, G. T. and **Rao, A. V.**, "Comparison of Global and Local Collocation Methods for Optimal Control," *Journal of Guidance, Control, and Dynamics*, Vol. 31, No. 2, March–April 2008, pp. 432–436. https://doi.org/10.2514/1.30915.

48. Huntington, G. T. and **Rao, A. V.**, "Optimal Reconfiguration of Spacecraft Formations Using the Gauss Pseudospectral Method," *Journal of Guidance, Control, and Dynamics*, Vol. 31, No. 3, May–June 2008, pp. 689–698. https://doi.org/10.2514/1.31083.

49. Huntington, G. T., Benson, D. A., and **Rao, A. V.**, "Optimal Configuration of Tetrahedral Spacecraft Formations," *The Journal of the Astronautical Sciences*, Vol. 55, No. 2, April–June 2007, pp. 141–169. https://doi.org/10.1007/BF03256518.

50. Benson, D. A., Huntington, G. T., Thorvaldsen, T. P., and **Rao, A. V.**, "Direct Trajectory Optimization and Costate Estimation via an Orthogonal Collocation Method," *Journal of Guidance, Control, and Dynamics*, Vol. 29, No. 6, November–December, 2006, pp. 1435–1440. https://doi.org/10.2514/1.20478.

————————Above This Line: Publications Since Joining University of Florida————————

51. **Rao, A. V.**, "Riccati Dichotomic Basis Method for Solving Hyper-Sensitive Optimal Control Problems," *Journal of Guidance, Control, and Dynamics*, Vol. 26, No. 1, January–February, 2003, pp. 185–189. https://doi.org/10.2514/2.5035.

52. **Rao, A. V.**, Tang, S., Hallman, W. P., "Numerical Optimization Study of Multiple-Pass Aeroassisted Orbital Transfer," *Optimal Control Applications and Methods*, Vol. 23, No. 4, July–August, 2002, pp. 215–238. https://doi.org/10.1002/oca.711.

53. **Rao, A. V.**, "Application of a Dichotomic Basis Method to Performance Optimization of Supersonic Aircraft," *Journal of Guidance, Control, and Dynamics*, Vol. 23, No. 4, July–August, 2002, pp. 570–573. https://doi.org/10.2514/2.4570.

54. **Rao, A. V.**, "Minimum-Variance Estimation of Reentry Debris Trajectories," *Journal of Spacecraft and Rockets*, Vol. 37, No. 3, May–June, 2000, pp. 366-373. https://doi.org/10.2514/2.3570.

55. **Rao, A. V.** and Mease, K. D., "Eigenvector Approximate Dichotomic Basis Method for Solving Hyper-Sensitive Optimal Control Problems," *Optimal Control Applications and Methods*, Vol. 21, No. 1, January–February, 2000, pp. 1–17 (republished from original version in Vol. 20, No. 2, 1999, due to publisher error). https://doi.org/10.1002/(SICI)1099-1514(200001/02)21:1<1::AID-OCA646>3.0.CO;2-V.

56. **Rao, A. V.** Mease, K. D., "Dichotomic Basis Approach to Solving Hyper-Sensitive Optimal Control Problems," *Automatica*, Vol. 35, No. 4, April 1999, pp. 633–642. https://doi.org/10.1016/S0005-1098(98)00161-7.

57. Bharadwaj, S, **Rao, A. V.**, and Mease, K. D., "Entry Trajectory Tracking Law via Feedback Linearization," *Journal of Guidance, Control, and Dynamics*, Vol. 21, No. 5, September–October, 1998, pp. 726–732. https://doi.org/10.2514/2.4318.

CONFERENCE PUBLICATIONS

1. Palmer, E. and **Rao, A. V.**, "Mars Entry Optimal Trajectory Generation, Guidance, and Control," *2022 AIAA Space Flight Mechanics Meeting*, 3–7 January 2022, San Diego, California, Accepted for Publication.

2. Pager, E. R. and **Rao, A. V.**, "Structure Identification Method for Nonsmooth and Singular Optimal Control Problems," *2022 AIAA Guidance, Navigation, and Control Conference*, 3–7 January 2022, San Diego, California, Accepted for Publication.

3. Holden, B. V. and **Rao, A. V.**, "Minimum-Fuel LEO-to-MEO Orbit Transfer Using Adaptive Gaussian Quadrature Collocation," *2022 AIAA Space Flight Mechanics Meeting*, 3–7 January 2022, San Diego, California, Accepted for Publication.

4. Abadia, G. and **Rao, A. V.**, "Continuation Method for the Numerical Solution of Singular Optimal Control Problems Using Adaptive Radau Collocation," *2022 AIAA Space Flight Mechanics Meeting*, 3–7 January 2022, San Diego, California, Accepted for Publication.

5. Keil, R. E., Miller, A., Kumar, M., and **Rao, A. V.**, "Biased Kernel Density Estimators for Chance Constrained Optimal Control Problems," *2020 American Control Conference (ACC)*, Denver, CO, USA, July 2020, pp. 2820–2825, 10.23919/ACC45564.2020.9148040.

6. Agamawi, Y. M. and **Rao, A. V.**, "Mesh Refinement Method for Solving Bang-Bang Optimal Control Problems Using Direct Collocation,", *2020 AIAA Guidance, Navigation, and Control Conference*, AIAA Paper 2020-0378, Orlando, Florida, 6–10 January 2020. https://doi.org/10.2514/6.2017-1506

7. Agamawi, Y. M. and **Rao, A. V.**, "Comparison of Derivative Estimation Methods in Solving Optimal Control Problems Using Direct Collocation,", *2020 AIAA Guidance, Navigation, and Control Conference*, AIAA Paper 2020-0376, Orlando, Florida, 6–10 January 2020. https://doi.org/10.2514/6.2020-0376

8. Dennis, M. and **Rao, A. V.,**, "Performance Optimization and Guidance of a Low-Altitude Skid-to-Turn Vehicle. Part II: Optimal Guidance," *2019 AIAA Guidance, Navigation, and Control Conference*, AIAA Paper 2019-0355, San Diego, California, 7 - 11 January 2019. https://doi.org/10.2514/6.2019-0355

9. Dennis, M. and **Rao, A. V.,**, "Performance Optimization and Guidance of a Low-Altitude Skid-to-Turn Vehicle. Part I: Performance Optimization," *2019 AIAA Guidance, Navigation, and Control Conference*, AIAA Paper 2019-0354, San Diego, California, 7 - 11 January 2019. https://doi.org/10.2514/6.2019-0354

10. Keil, R., Aggarwal, R., Kumar, M., and **Rao, A. V.,**, "Application of Chance-Constrained Optimal Control to Optimal Obstacle Avoidance," *2019 AIAA Guidance, Navigation, and Control Conference*, San Diego, California, 7 - 11 January 2019. https://doi.org/10.2514/6.2019-0647

11. Eide, J. D., Hager, W. W., and **Rao, A. V.**, "Modified Radau Collocation Method for Solving Optimal Control Problems with Nonsmooth Solutions Part II: Costate Estimation and the Transformed Adjoint System," *2018 IEEE Conference on Decision and Control (CDC)*, Miami Beach, FL, 2018, pp. 1651–1656, 10.1109/CDC.2018.8619426.

12. Eide, J. D., Hager, W. W., and **Rao, A. V.**, "Modified Radau Collocation method for Solving Optimal Control Problems with Nonsmooth Solutions Part I: Lavrentiev Phenomenon and the Search Space," *2018 IEEE Conference on Decision and Control (CDC)*, Miami Beach, FL, 2018, pp. 1644–1650, 10.1109/CDC.2018.8619830.

13. Agamawi, Y. and **Rao, A. V.**, "Exploiting Sparsity in Direct Collocation Pseudospectral Methods for Solving Multiple-Phase Optimal Control Problems," *2018 AIAA/AAS Space Flight Mechanics Meeting*, AIAA Paper 2018-0852, Kissimmee, Florida, 8 - 12 January 2018. https://doi.org/10.2514/6.2018-0724.

14. Miller, A. T., Hager, W. W., and **Rao, A. V.**, "A Preliminary Analysis of Mesh Refinement for Optimal Control Using Discontinuity Detection via Jump Function Approximations," *2018 AIAA Guidance, Navigation, and Control Conference*, Kissimmee, Florida, 8 - 12 January 2018. Submitted for Publication, June 2017.AIAA Paper 2018-0852, Kissimmee, Florida, 8 - 12 January 2018. https://doi.org/10.2514/6.2018-0852.

15. Hager W. W. and **Rao, A. V.**, "Mesh-Generation Method for Real-Time Optimal Control Using Adaptive Gaussian Quadrature Collocation," *2018 AIAA Guidance, Navigation, and Control Conference*, AIAA Paper 2018-0848, Kissimmee, Florida, 8 - 12 January 2018. https://doi.org/10.2514/6.2018-0848.

16. Fuhr, R. and **Rao, A. V.**, "Minimum-Impulse Low-Earth Orbit Aeroassisted Orbital Transfer with Heating Constraints," *2018 AIAA/AAS Space Flight Mechanics Meeting*, AIAA Paper 2018-0967, Kissimmee, Florida, 8 - 12 January 2018. https://doi.org/10.2514/6.2018-0967.

17. Agamawi, Y., Hager, W. W., and **Rao, A. V.**, "Mesh Refinement Method for Optimal Control Problems with Discontinuous Control Profiles," *2017 AIAA Guidance, Navigation, and Control Conference*, AIAA Paper 2017-1506, 9–13 January 2017, Grapevine, Texas. https://doi.org/10.2514/6.2017-1506

18. Miller, A. T. and **Rao, A. V.**, "Rapid Ascent-Entry Vehicle Mission Optimization Using hp-Adaptive Gaussian Quadrature Collocation," *2017 AIAA Atmospheric Flight Mechanics Conference*, AIAA Paper 2017-0249, 9 – 13 January 2017, Grapevine, Texas. https://doi.org/10.2514/6.2017-0249

19. Eide, J. and **Rao, A. V.**, "Lavrentiev Phenomenon in *hp* Gaussian Quadrature Collocation Methods for Optimal Control," *2016 AIAA/AAS Astrodynamics Specialist Conference*, AIAA Paper 2016-5575, 13–16 September 2016, Long Beach, California. https://doi.org/10.2514/6.2016-5575.

20. Zhao, Z., Liu, F., Kumar, M., and **Rao, A. V.**, "A Novel Approach to Chance Constrained Optimal Control Problems," *2015 American Control Conference (ACC)*, Chicago, IL, 2015, pp. 5611–5616, https://doi.org/10.1109/ACC.2015.7172218.

21. Graham, K. F. and **Rao, A. V.**, "Mesh Refinement for Low-Thrust Trajectory Optimization of Earth-Orbit Transfers," *2015 AAS/AIAA Space Flight Mechanics Meeting*, AAS Paper 15-434, Williamsburg, Virginia, 11 - 15 January 2015.

22. Graham, K. F. and **Rao, A. V.**, "Low-Thrust Trajectory Optimization of Earth-Orbit Transfers with Eclipsing Constraints," *2015 AAS/AIAA Space Flight Mechanics Meeting*, AAS Paper 15-438, Williamsburg, Virginia, 11 - 15 January 2015.

23. Weinstein, M. A., Patterson, M. A., and **Rao, A. V.**, "Utilizing the Algorithmic Differentiation Package ADiGator for Solving Optimal Control Problems Using Direct Collocation," *2015 AIAA Guidance, Navigation, and Control Conference*, Kissimmee, FL, January 2015. https://doi.org/10.2514/6.2015-1085.

24. Şenses, B., Davis. T. A., and **Rao, A. V.**, "Graph Coarsening Method for Solving KKT Systems Arising in Orthogonal Collocation of Optimal Control Problems," *2015 AIAA Modeling and Simulation Technologies Conference*, Kissimmee, FL, 4 - 7 January 2015. https://doi.org/10.2514/6.2015-0142.

25. Liu, F., Hager, W. W., **Rao, A. V.**, "An hp Mesh Refinement Method for Optimal Control Using Discontinuity Detection and Mesh Size Reduction," *53rd IEEE Conference on Decision and Control*, Los Angeles, CA, 2014, pp. 5868–5873. https://doi.org/10.1109/CDC.2014.7040308.

26. Françolin, C. C., Hou, H., Hager, W. W., and **Rao, A. V.**, "Costate Estimation of State-Inequality Path Constrained Optimal Control Problems Using Collocation at Legendre-Gauss-Radau Points," *52nd IEEE Conference on Decision and Control*, Florence, Italy, 2013, pp. 6469–6474. https://doi.org/10.1109/CDC.2013.6760913.

27. Rexius, S. L., Rexius, T. E., Jorris, T. R., and **Rao, A. V.**, "Advances in Highly Constrained Multi-Phase Trajectory Generation Using the General Pseudospectral Optimization Software GPOPS," *2013 AIAA Guidance, Navigation, and Control Conference*, AIAA Paper 2013–4950, 19–22 August 2013, Boston, Massachuetts. https://doi.org/10.2514/6.2013-4950.

28. Schubert, K. F. and **Rao, A. V.**, "Minimum-Time Low-Earth Orbit to High-Earth Orbit Low Thrust Trajectory Optimization, *2013 AAS/AIAA Astrodynamics Specialist Conference*, AAS Paper 13-926, Hilton Head, South Carolina, 12–15 August 2013. **(Paper Chosen for American Astronautical Society John V. Breakwell Student Travel Award)**

29. Françolin, C. and **Rao, A. V.**, "Direct Trajectory Optimization and Costate Estimation of State Inequality Path-Constrained Optimal Control Problems Using a Radau Pseudospectral Method," *2012 AIAA Guidance, Navigation, and Control Conference*, AIAA Paper 2012–4528, Minneapolis, Minnesota, August 13–16, 2012. https://doi.org/10.2514/6.2012-4528.

30. Hou, H., Hager, W. W., and **Rao, A. V.**, "Convergence of a Gauss Pseudospectral Method for Optimal Control," *2012 AIAA Guidance, Navigation, and Control Conference*, AIAA Paper 2012–4452, Minneapolis, Minnesota, August 13–16, 2012. https://doi.org/10.2514/6.2012-4452.

31. Şenses, B. and **Rao, A. V.**, "A Preliminary Analysis of Small Spacecraft Finite-Thrust Aeroassisted Orbital Transfer," *2012 AIAA/AAS Astrodynamics Specialist Conference*, AIAA Paper 2012–4812, Minneapolis, Minnesota, August 13–16, 2012. https://doi.org/10.2514/6.2012-4812.

32. Weinstein, M., Patterson, M. A., and **Rao, A. V.**, "A Method for Computing Derivatives in MATLAB," *2012 AIAA/AAS Astrodynamics Specialist Conference*, AIAA Paper 2012–4521, Minneapolis, Minnesota, August 13–16, 2012. https://doi.org/10.2514/6.2012-4521.

33. Mohan, K., Patterson, M. A., and **Rao, A. V.**, "Optimal Trajectory and Control Generation for Landing of Multiple Aircraft in the Presence of Obstacles," *2012 AIAA Guidance, Navigation, and Control Conference*, AIAA Paper 2012–4826, Minneapolis, Minnesota, August 13–16, 2012. https://doi.org/10.2514/6.2012-4826.

34. Darby, C. L., Garg, D., and **Rao, A. V.**, "Costate Estimation Using Multiple-Interval Pseudospectral Methods," *2011 AIAA Guidance, Navigation, and Control Conference*, AIAA Paper 2011–6571, Portland, Oregon, August 8–11, 2011. https://doi.org/10.2514/6.2011-6571.

35. Darby, C. L, Hager, W. W., and **Rao, A. V.**, "A Preliminary Analysis of a Variable-Order Approach to Solving Optimal Control Problems Using Pseudospectral Methods," *2011 AIAA/AAS Astrodynamics Specialist Conference*, AIAA Paper 2010–8272, Toronto, Ontario, Canada, August 2–5, 2010. https://doi.org/10.2514/6.2010-8272.

36. Françolin, C., **Rao, A. V.**, Duarte, C., and Martel, G., "Optimization of the Motion of a Mobile Gateway to Improve Connectivity in a Network of Autonomous Underwater Vehicles," *AIAA Guidance, Navigation, and Control Conference*, AIAA Paper 2010–7572, Toronto, Ontario, Canada, August 2–5, 2010. https://doi.org/10.2514/6.2010-7572.

37. Patterson, M. A. and **Rao, A. V.**, "An Object-Oriented Method for Computation of Analytic Derivatives," *AIAA Modeling and Simulation Technologies Conference*, AIAA Paper 2010–7783, Toronto, Ontario, Canada, August 2–5, 2010. https://doi.org/10.2514/6.2010-7783.

38. Garg, D., Hager, W. W., and **Rao, A. V.**, "Gauss Pseudospectral Method for Solving Infinite-Horizon Optimal Control Problems," *AIAA Guidance, Navigation, and Control Conference*, AIAA Paper 2010–7890, Toronto, Ontario, Canada, August 2–5, 2010. https://doi.org/10.2514/6.2010-7890.

39. Jorris, T. R. and **Rao, A. V.**, "Bang-Bang Trajectory Optimization Using Autonomous Phase Placement and Mesh Refinement Satisfying Waypoint and No-Fly Zone Constraints," *AAS/AIAA Space Flight Mechanics Meeting*, AAS Paper Number 10–115, San Diego, California, February 15–17, 2010.

40. Darby, C. L. and **Rao, A. V.**, "Optimal Impulsive LEO to LEO Aeroassisted Orbital Transfer of Small Satellites," *AAS/AIAA Space Flight Mechanics Meeting*, AAS Paper Number 10–102, San Diego, California, February 15–17, 2010.

41. **Rao, A. V.**, "A Survey of Numerical Methods for Optimal Control," AAS/AIAA Astrodynamics Specialist Conference, AAS Paper 09–334, Pittsburgh, PA, August 10–13, 2009.

42. Garg, D., Patterson, M. A., Hager, W. W., **Rao, A. V.**, Benson, D. A., and Huntington, G. T., "An Overview of Three Pseudospectral Methods for The Numerical Solution of Optimal Control Problems," *AAS/AIAA Astrodynamics Specialist Conference*, Pittsburgh, PA, August 10–13, 2009.

43. Garg, D., Patterson, M. A., Darby, C. L. Françolin, C., Huntington, G. T., Hager, W. W, and **Rao, A. V.**, "Direct Trajectory Optimization and Costate Estimation of General Optimal Control Problems Using a Radau Pseudospectral Method," *AIAA Guidance, Navigation, and Control Conference*, AIAA Paper 2009–5989, Chicago, IL, August 10–13, 2009. https://doi.org/10.2514/6.2009-5989.

44. Darby, C. L. and **Rao, A. V.**, "A State Approximation-Based Mesh Refinement Algorithm for Solving Optimal Control Problems Using Pseudospectral Methods," *AIAA Guidance, Navigation, and Control Conference*, AIAA Paper 2009–5791, Chicago, IL, August 10-13, 2009. https://doi.org/10.2514/6.2009-5791.

45. Darby, C. L. and **Rao, A. V.**, "An Initial Examination of Using Pseudospectral Methods for Time-Scale and Differential Geometric Analysis of Nonlinear Optimal Control Problems," *AIAA/AAS Astrodynamics Specialist Conference*, AIAA Paper 2008–6449, Honolulu, Hawaii, August 18–21, 2008. https://doi.org/10.2514/6.2008-6449.

46. **Rao, A. V.**, Scherich, A. W., Cox, S., and Mosher, T., "A Concept for Operationally Responsive Space Mission Planning Using Aeroassisted Orbital Transfer," *AIAA Responsive Space Conference*, AIAA Paper RS6-2008-1001, Los Angeles, California, 28 April–1 May, 2008.

47. Matsumura, T., Gogu, C., Haftka, R., and **Rao, A. V.**, "Aeroassisted Orbital Transfer Trajectory Optimization Considering Thermal Protection System Mass," *AIAA Aerospace Sciences Meeting*, AIAA Paper 2008–898, Reno, Nevada, January 7–10, 2008. https://doi.org/10.2514/6.2008-898.

48. Huntington, G. T., Benson, D. A., How, J. P., Kanizay, N., Darby, C. L., and **Rao, A. V.**, "Computation of Boundary Controls Using a Gauss Pseudospectral Method," *AAS/AIAA Astrodynamics Specialist Conference*, AAS Paper 07–381, Mackinac Island, Michigan, August 20–23, 2007.

49. Huntington, G. T., Benson, D. A., and **Rao, A. V.**, "A Comparison of Accuracy and Computational Efficiency of Three Pseudospectral Methods," *AIAA Guidance, Navigation, and Control Conference*, AIAA Paper 2007–6405, Hilton Head, SC, August 20–23, 2007. https://doi.org/10.2514/6.2007-6405.

50. Huntington, G. T., and **Rao, A. V.**, "A Comparison between Global and Local Orthogonal Collocation Methods for Solving Optimal Control Problems," *2007 American Control Conference*, New York, NY, July 11–13, 2007, pp. 1950–1957, https://doi.org/10.1109/ACC.2007.4282393.

51. Huntington, G. T., Benson, D. A., and **Rao, A. V.**, "Post-Optimality Analysis and Evaluation of a Formation Flying Problem via a Gauss Pseudospectral Method," *AAS/AIAA Astrodynamics Specialist Conference*, Lake Tahoe, California, August 7–11 2005.

————————Above This Line: Publications Since Joining University of Florida————————

52. Huntington, G. T. and **Rao, A. V.**, "Optimal Reconfiguration of Tetrahedral Spacecraft Formations via a Gauss Pseudospectral Method," *AAS/AIAA Astrodynamics Specialist Conference*, Lake Tahoe, California, August 7–11 2005.

53. Huntington, G. T. and **Rao, A. V.**, "Optimal Configuration of Tetrahedral Spacecraft Formations via a Gauss Pseudospectral Method," *AAS/AIAA Space Flight Mechanics Meeting*, Copper Mountain, Colorado, January 23–27 2005.

54. **Rao, A. V.**, "Extension of a Pseudospectral Legendre Method to Non-Sequential Multiple-Phase Optimal Control Problems," *AIAA Guidance, Navigation, and Control Conference*, AIAA Paper 2003–5634, Austin, TX, August 11–14, 2003. https://doi.org/10.2514/6.2003-5634.

55. **Rao, A. V.** and Clarke, K. A., "Performance Optimization of a Maneuvering Re-entry Vehicle via a Legendre Pseudospectral Method," *AIAA Atmospheric Flight Mechanics Conference*, AIAA Paper 2002–4885, Monterey, CA, August 6-9, 2002. https://doi.org/10.2514/6.2002-4885.

56. **Rao, A. V.**, "Riccati Dichotomic Basis Method for Solving Hyper-Sensitive Optimal Control Problems," *AIAA Guidance, Navigation, and Control Conference*, Montreal, Quebec, August 6–9, 2001. https://doi.org/10.2514/6.2001-4225.

57. **Rao, A. V.**, "Numerical Optimization Study of Multiple-Pass Aeroassisted Orbital Transfer," *AIAA Guidance, Navigation, and Control Conference*, Denver, Colorado, August 5–8, 2000. https://doi.org/10.2514/6.2000-3995.

arXiV Articles

1. Agamawi, Y. M. and **Rao, A. V.**, "CGPOPS: A C++ Software for Solving Multiple-Phase Optimal Control Problems Using Adaptive Gaussian Quadrature Collocation and Sparse Nonlinear Programming,", 29 May 2019. Cite as arXiv:1905.11898.

2. Agamawi, Y. M., Hager, W. W., and **Rao, A. V.**, "Mesh Refinement Method for Solving Bang-Bang Optimal Control Problems Using Direct Collocation,", *Journal of Guidance, Control, and Dynamics*, 30 May 2019. Cite as arXiv:1905.11895.

3. Agamawi, Y. M. and **Rao, A. V.**, "Comparison of Derivative Estimation Methods in Solving Optimal Control Problems Using Direct Collocation,", *AIAA Journal*, 29 May 2019. Cite as arXiv:1905.12745.

4. Hager, W. W., Mohapatra, S., and **Rao, A. V.**, "Convergence Rate for a Gauss Collocation Method Applied to Constrained Optimal Control," July 10, 2016. Revised September 30, 2016. Cite as arXiv:1607.02798.

5. Hager, W. W., Hou, H., Mohapatra, S., and **Rao, A. V.**, "Convergence Rate for an *hp* Collocation Method Applied to Unconstrained Optimal Control," May 6, 2016. Cite as arXiv:1605.02121.

6. Hager, W. W., Hou, H., and **Rao, A. V.**, "Convergence Rate for a Radau Collocation Method Applied to Unconstrained Optimal Control," August 17, 2015. Revised September 12, 2015. Cite as arXiv:1508.03783.

BOOKS

Rao, A. V., *Dynamics of Particles and Rigid Bodies: A Systematic Approach*, Cambridge University Press, 2006, 528 pages.

ENCYCLOPEDIA ARTICLES

Rao, A. V., "Trajectory Optimization," *Encyclopedia of Aerospace Engineering*, John Wiley and Sons, 2010.

EDITED VOLUMES

Rao, A. V., Lovell, T. A., Chan, F. K., and Cangahuala, L. A., Eds., *Advances in the Astronautical Sciences*, Vol. 135, Univelt Publishers, San Diego, August 2009, 2446 pages.

SOFTWARE

1. Agamawi, Y. M. and **Rao, A. V.**, CGPOPS: A C++ Software for Solving Multiple-Phase Optimal Control Problems Using Adaptive Gaussian Quadrature Collocation and Sparse Nonlinear Programming. https://arxiv.org/abs/1905.12745.

2. Patterson, M. A., and **Rao, A. V.**, GPOPS – II: A MATLAB Software for Solving Multiple-Phase Optimal Control Problems Using Sparse Nonlinear Programming and *hp*-Adaptive Pseudospectral Methods. http://www.gpops2.com.

3. Weinstein, M. J. and **Rao, A. V.**, ADiGator, a MATLAB Software for Algorithmic Differentiation of Mathematical Functions Using Source Transformation via Operator Overloading. http://sourceforge.net/projects/adigator.

4. **Rao, A. V.**, Benson, D. A., Patterson, M. A., Françolin, C. C., Sanders, I., and Huntington, G. T., GPOPS: A MATLAB Software for Solving Optimal Control Problems Using Gauss Quadrature Collocation. Algorithm 902 Collected Algorithms of the Association of Computing Machinery. http://calgo.acm.org.

GRADUATED Ph.D. STUDENTS

Student Name	Institution	Date Awarded	Current Employer
Dr. Alexander Miller	University of Florida	August 2021	Johns Hopkins Applied Physics Laboratory
Dr. Rachel Keil	University of Florida	August 2020	Johns Hopkins Applied Physics Laboratory
Dr. Miriam Dennis	University of Florida	August 2020	Air Force Research Laboratory - Edwards Air Force Base
Dr. Yunus Agamawi	University of Florida	August 2019	Johns Hopkins Applied Physics Laboratory
Dr. Fengjin Liu	University of Florida	December 2015	Snapchat
Dr. Kathryn F. Graham	University of Florida	December 2015	Utah State University
Dr. Begum Cannataro	University of Florida	August 2015	Draper Laboratory
Dr. Matthew J. Weinstein	University of Florida	May 2015	Draper Laboratory
Dr. Camila C. Françolin	University of Florida	August 2013	Draper Laboratory
Dr. Michael A. Patterson	University of Florida	May 2013	Johns Hopkins Applied Physics Laboratory
Dr. Divya Garg	University of Florida	August 2011	Intel Corporation
Dr. Christopher L. Darby	University of Florida	April 2011	Intel Corporation
Dr. Geoffrey T. Huntington	MIT	May 2007	Blue Origin Federation, LLC

CURRENT Ph.D. STUDENTS

Student Name	Institution	Expected Completion Date
Cale Byczkowski	University of Florida	May 2025
George Haman III	University of Florida	May 2025
Emily Palmer	University of Florida	May 2025
Gabriela Abadia	University of Florida	May 2025
Elisha Pager	University of Florida	August 2022
Brittanny Holden	University of Florida	August 2022
Joseph Eide	University of Florida	December 2021

TEACHING EVALUATIONS (UNIVERSITY OF FLORIDA)

Course Number	Course Name	Semester Taught	Course Enrollment	Rao Overall Evaluation	Department Mean	College Mean
EAS 4510	Astrodynamics	Spring 2018	110	**4.92**	4.10	4.07
EAS 4510	Astrodynamics	Spring 2019	152	**4.89**	4.13	4.14
EAS 4510	Astrodynamics	Spring 2020	122	**4.81**	4.18	4.21
EAS 4510	Astrodynamics	Fall 2020	45	**4.63**	4.07	4.25
EGM 3400	Elements of Dynamics	Spring 2007	38	**4.60**	4.00	4.17
EGM 3400	Elements of Dynamics	Fall 2008	74	**4.75**	4.10	4.19
EGM 3400	Elements of Dynamics	Fall 2010	40	**4.64**	4.14	4.21
EGM 3401	Engineering Dynamics	Spring 2007	53	**4.70**	4.00	4.17
EGM 3401	Engineering Dynamics	Fall 2008	82	**4.79**	4.10	4.19
EGM 3401	Engineering Dynamics	Fall 2010	104	**4.66**	4.14	4.21
EGM 3401	Engineering Dynamics	Spring 2011	85	**4.76**	4.12	4.11
EGM 3401	Engineering Dynamics	Spring 2013	280	**4.57**	4.16	4.15
EGM 3401	Engineering Dynamics	Fall 2014	103	**4.62**	4.07	4.13
EGM 3401	Engineering Dynamics	Spring 2015	81	**4.90**	4.13	4.14
EGM 3401	Engineering Dynamics	Fall 2016	232	**4.85**	4.18	4.15
EGM 3401	Engineering Dynamics	Spring 2017	111	**4.93**	4.21	4.16
EGM 3401	Engineering Dynamics	Spring 2018	90	**4.88**	4.10	4.07
EGM 3401	Engineering Dynamics	Fall 2018	149	**4.91**	4.21	4.22
EGM 3401	Engineering Dynamics	Spring 2021	139	**4.54**	4.24	4.25
EML 4220	Mechanical Vibrations	Fall 2006	128	**4.54**	3.99	4.13
EML 4220	Mechanical Vibrations	Spring 2009	151	**4.57**	4.10	4.19
EML 4220	Mechanical Vibrations	Fall 2012	51	**4.48**	4.17	4.19
EML 5215	Analytical Dynamics	Fall 2007	35	**4.54**	3.99	4.14
EML 5215	Analytical Dynamics	Fall 2009	45	**4.75**	4.14	4.18
EML 5215	Analytical Dynamics	Fall 2011	49	**4.67**	4.11	4.17
EML 5215	Analytical Dynamics	Fall 2013	31	**4.14**	4.05	4.17
EML 6934	Optimal Control	Spring 2008	19	**4.53**	4.08	4.20
EML 6934	Optimal Control	Spring 2010	29	**4.35**	4.10	4.17
EML 6934	Optimal Control	Spring 2012	23	**4.50**	4.20	4.17
EML 6934	Optimal Control	Spring 2014	9	**4.56**	4.09	4.14
EML 6934	Optimal Control	Fall 2017	27	**4.77**	4.44	4.40
EML 6934	Optimal Control	Fall 2019	16	**4.68**	4.40	4.43

Notes:

- Prior to the 2019–2020 acacemic year
  - Publicly available University of Florida teaching evalutions can be found at https://evaluations.ufl.edu/evals/Default.aspx.
  - The category "overall instructor evaluation" is an actual question on the evaluations.
- From 2019–2020 onwards

– Course evaluations can be found at https://gatorevals.aa.ufl.edu/public-results/.

– The category "overall instructor evaluation" is the average of the responses to a series of questions regarding the course.

EXTERNAL RESEARCH FUNDING

Total Funding as PI or Co-PI	$7,001,997
Agency	U.S. Air Force Research Laboratory
Role	Principal Investigator
Title	Solutions to Optimal Control Problems for Boost Glide High-Speed Applications
Period of Performance	August 2021 to August 2024
Amount	$295,247
Agency	National Science Foundation
Role	Principal Investigator (Co-PI: W. Hager)
Title	Improved Numerical Methods for Solving Optimal Control Problems with Nonsmooth and Singular Solutions
Period of Performance	January 2021 to December 2023
Amount	$609,025
Agency	NASA Florida Space Grant Consortium
Role	Principal Investigator
Title	Novel Computational Approach for Optimal Debris Mitigation from Low-Earth Orbit
Period of Performance	August 2020 to August 2021
Amount	$25,000
Agency	Lockheed-Martin Corporation
Role	Principal Investigator
Title	Methods for Solving Optimal Control Problems with Nonsmooth Solutions
Period of Performance	August 2019 to August 2020
Amount	$100,000
Agency	U.S. Office of Naval Research
Role	Principal Investigator (Co-PI: M. Hale)
Title	A Novel Computational Framework for Optimal Control of Multi-Agent Systems
Period of Performance	August 2019 to August 2022
Amount	$599,615
Agency	NASA Florida Space Grant Consortium
Role	Principal Investigator
Title	A Computational Approach for the Efficient and Accurate Solutions of Solar Sail Trajectory Optimization Problems
Period of Performance	August 2018 to December 2019
Amount	$25,000
Agency	National Science Foundation
Role	Co-Principal Investigator (PI: W. Hager)
Title	Polyhedral Techniques for Fast Sparse Nonlinear Optimization and Their Application to Nonsmooth Optimal Control
Period of Performance	August 2018 to July 2021
Amount	$200,000
Agency	National Science Foundation
Role	Principal Investigator (Co-PI: M. Kumar)
Title	A Computational Framework for Chance-Constrained Optimal Control
Period of Performance	July 2016 to June 2019
Amount	$400,000
Agency	U.S. Naval Air Systems Command (via Systems Technology, Inc)
Role	Principal Investigator (Co-PI: W. W. Hager)
Title	Phase II: Pseudospectral Optimal Control for Flight Trajectory Optimization
Period of Performance	January 2017 to January 2019
Amount	$295,580

Agency	U.S. Naval Air Systems Command (via Systems Technology, Inc)
Role	Principal Investigator (Co-PI: W. W. Hager)
Title	Phase I: Pseudospectral Optimal Control for Flight Trajectory Optimization
Period of Performance	July 2015 to October 2016
Amount	$72,500
Agency	U.S. Air Force Research Laboratory
Role	Principal Investigator (Co-PI: W. W. Hager)
Title	Solutions to Optimal Control Problems for Boost Glide High-Speed Applications
Period of Performance	September 2015 to September 2017
Amount	$358,842
Agency	NASA Florida Space Grant Consortium
Role	Principal Investigator
Title	A Novel Computational Approach to Solving Optimal Control Problems Whose Solutions Lie on Singular Arcs
Period of Performance	August 2015 to August 2016
Amount	$25,000
Agency	National Science Foundation
Role	Co-Principal Investigator (PI: W. W. Hager)
Title	Fast Sparse Nonlinear Optimization and Its Application to Optimal Control
Period of Performance	July 2015 to July 2018
Amount	$299,793
Agency	U.S. Office of Naval Research
Role	Co-Principal Investigator (PI: W. W. Hager)
Title	New Innovations in Large-Scale Sparse Optimization and Applications
Period of Performance	March 2015 to February 2018
Amount	$479,870
Agency	National Science Foundation
Role	Co-Principal Investigator (PI: B. J. Fregly)
Title	A Next-Generation Computation Framework for Predicting Optimal Walking Motion
Period of Performance	August 2014 to August 2017
Amount	$499,994
Agency	National Aeronautics and Space Administration
Role	Principal Investigator
Title	A Computational Approach for the Efficient and Accurate Solutions of Low-Thrust Trajectory Optimization Problems
Period of Performance	August 2014 to August 2015
Amount	$30,657
Agency	U. S. Space and Naval Warfare Systems Command
Role	Principal Investigator (Co-PI: M. Kumar)
Title	A Computational Approach for Probabilistically Constrained Design Optimization Using Generalized Polynomial Chaos and Pseudospectral Methods (Phase 1: gPC Modeling and Sparse Symmetric Linear Solver)
Period of Performance	September 2013 to December 2014
Amount	$247,083
Agency	NASA Florida Space Grant Consortium
Role	Principal Investigator
Title	A Novel Computational Framework for Efficient and Accurate Low-Thrust Optimal Mission Planning
Period of Performance	August 2013 to February 2015
Amount	$25,000
Agency	National Aeronautics and Space Administration
Role	Principal Investigator
Title	Low-Thrust Trajectory Optimization Using Pseudospectral Methods
Period of Performance	January 2012 to December 2012
Amount	$25,000

Agency	U. S. Defense Advanced Research Projects Agency
Role	Principal Investigator (Co-PI: W. W. Hager)
Title	A Computational Framework for the Rapid, Reliable, & Robust Solutions to Complex Constrained Optimal Control Problems
Period of Performance	October 2011 to October 2014
Amount	$986,684
Agency	U. S. Office of Naval Research
Role	Principal Investigator (Co-PI: W. W. Hager)
Title	A Computational Framework for the Real-Time Solution of Optimal Control Problems
Period of Performance	November 2010 to October 2013
Amount	$551,728
Agency	Advatech Pacific/U. S. Air Force Research Laboratory
Role	Principal Investigator
Title	Advancement in Computational Methods for Optimal Control Using Pseudospectral Methods
Period of Performance	September 2010 to May 2011
Amount	$75,000
Agency	U. S. Air Force Research Laboratory
Role	Principal Investigator
Title	A Pseudospectral Mission Planning Tool for Prompt Global Strike
Period of Performance	September 2009 to August 2010
Amount	$75,000
Agency	NASA Florida Space Grant Consortium
Role	Principal Investigator
Title	A Multi-Disciplinary Design Optimization Approach to Rapid Space Planning for Operationally Responsive Space
Period of Performance	August 2009 to August 2010
Amount	$16,000
Agency	Lockheed-Martin Corporation
Role	Co-Principal Investigator (PI: G. Wiens)
Title	Multi-Disciplinary Design Optimization of Aeroassisted Orbital Transfer
Period of Performance	January 2009 to December 2009
Amount	$95,000
Agency	U. S. Office of Naval Research
Role	Principal Investigator
Title	A Computational Approach for Autonomous Undersea Vehicle Near-Optimal Path Planning and Guidance
Period of Performance	September 2008 to August 2012
Amount	$224,379
Agency	U. S. Army Research Office
Role	Principal Investigator (Co-PI: W. W. Hager)
Title	A Computational Framework for Path Planning and Guidance for Dynamical Systems with Nonholonomic Constraints
Period of Performance	September 2008 to June 2009
Amount	$50,000
Agency	NASA Florida Space Grant Consortium
Role	Principal Investigator
Title	Student Award for Trajectory Optimization
Period of Performance	August 2008 to August 2009
Amount	$10,000
Agency	NASA Florida Space Grant Consortium
Role	Principal Investigator
Title	A Computational Approach for Rapid Space Mission Planning
Period of Performance	August 2007 to August 2008

Amount	$25,000
Agency	ATK Launch Systems
Role	Principal Investigator
Title	Launch Vehicle Ascent Guidance Using Pseudospectral Methods
Period of Performance	July 2007 to August 2008
Amount	$65,000
Agency	ATK Launch Systems
Role	Principal Investigator
Title	Launch Vehicle Ascent Guidance Using Pseudospectral Methods
Period of Performance	January 2007 to June 2007
Amount	$60,000
Agency	National Aeronautics and Space Administration
Role	Principal Investigator
Title	Legendre Pseudospectral Method for Multiple Spacecraft Formation Flying
Period of Performance	July 2003 to June 2006
Amount	$180,000

INVITED TALKS

Institution	Topic	Dates
University of Texas at Austin	Next-Generation Computational Framework for Rapid and Reliable Solutions to Optimal Control Problems	April 2021
Pennsylvania State University	Next-Generation Computational Framework for Rapid and Reliable Solutions to Optimal Control Problems	March 2017
University of Cincinnati	Next-Generation Computational Framework for Rapid and Reliable Solutions to Optimal Control Problems	November 2016
University of Texas at Arlington	Next-Generation Computational Framework for Rapid and Reliable Solutions to Optimal Control Problems	September 2016
International Conference on Continuous Optimization (ICCOPT 2016)	Novel Computational Framework for the Numerical Solution of Constrained Optimal Control Problems	August 2016
Georgia Institute of Technology	Next-Generation Computational Framework for Rapid and Reliable Solutions to Optimal Control Problems	March 2016
University of Edinburgh – International Symposium for Computer Simulation in Biomechanics	Numerical Methods for Optimal Control	July 2015
Imperial College of Science & Technology – 2015 British-French-German Conference on Optimization	Graph Coarsening of KKT Systems Arising in Orthogonal Collocation Methods for Optimal Control	June 2015
Clemson University	Next-Generation Computational Framework for Rapid and Reliable Solutions to Optimal Control Problems	April 2015
Oxford University	Pseudospectral Methods: Theory and Practice	March 2014
Embry-Riddle Aeronautical University	Next-Generation Computational Framework for Rapid and Reliable Solutions to Optimal Control Problems	January 2014
Johannes Kepler University – Workshop on Optimization and Optimal	Survey of Numerical Methods for Optimal Control Control	July 2013

Oxford University	Pseudospectral Methods: Theory and Practice	December 2012
McGill University – 2012 Bellairs Workshop on Computer Graphics & Animation	Pseudospectral Methods: for Optimal Control for Computer Animation	March 2012
University of Toronto	Next-Generation Computational Framework for Rapid and Reliable Solutions to Optimal Control Problems	March 2012
George Washington University	Next-Generation Computational Framework for Rapid and Reliable Solutions to Optimal Control Problems	April 2010
Georgia Institute of Technology	Next-Generation Computational Framework for Rapid and Reliable Solutions to Optimal Control Problems	March 2010
University of Illinois at Urbana – Champaign	Next-Generation Computational Framework for Rapid and Reliable Solutions to Optimal Control Problems	March 2010

CONSULTING AND SHORT COURSES

Institution	Work Performed	Dates
National Air and Space Intelligence Center	Short Course on Optimal Control	July 2018
Lockheed-Martin Space Systems	Optimal Control Consulting	August 2017
NASA Goddard Space Flight Center	Short Course on Optimal Control	July 2016
Doolittle Institute (Eglin Air Force Base)	Short Course on Optimal Control	December 2015
Edwards Air Force Base	Short Course on Optimal Control	August 2015
MITRE Corporation	Optimal Control Consulting	July 2015 – Present
Doolittle Institute (Eglin Air Force Base)	Short Course on Optimal Control	October 2014
Edwards Air Force Base	Short Course on Optimal Control	September 2014
Kirtland Air Force Base	Short Course on Optimal Control	July 2014
Doolittle Institute (Eglin Air Force Base)	Short Course on Optimal Control	May 2014
Edwards Air Force Base	Short Course on Optimal Control	March 2013
Advatech Pacific	Optimal Control Consulting	Throughout 2010 – 2011
Analytical Graphics, Inc.	Short Course on Optimal Control	May 2010

PROFESSIONAL SERVICE

Role	Service	Dates of Service
Member, Space Flight Mechanics Technical Committee	American Astronautical Society	September 2016 to Present
General Chair	2012 AIAA/AAS Astrodynamics Specialist Conference	August 2012
Technical Chair	2009 AAS/AIAA Astrodynamics Specialist Conference	August 2009
Associate Editor	Journal of the Astronautical Sciences	November 2006 to Date
Associate Editor	Journal of Optimization Theory and Applications	June 2011 to Date
Associate Editor	Journal of Spacecraft and Rockets	January 2015 to Date
Member, Space Flight Mechanics Technical Committee	American Astronautical Society	January 2007 to August 2013
Member, Publications Committee Technical Committee	American Institute of Aeronautics and Astronautics	January 2009 to December 2011

HONORS AND AWARDS

Award	Institution Conferring Award	Date of Award
University of Florida Term Professorship	Herbert Wertheim College of Engineering University of Florida	August 2021 – 2024
Fellow	American Astronautical Society	2020
University of Florida Term Professorship	Herbert Wertheim College of Engineering University of Florida	August 2017 – 2020
Erich Farber Faculty Fellow	Department of Mechanical & Aerospace Engineering University of Florida	November 2016
Pramod P. Khargonekar Junior Faculty Award	College of Engineering University of Florida	July 2012
Associate Fellow	American Institute of Aeronautics and Astronautics	January 2011
Teacher of the Year	Department of Mechanical & Aerospace Engineering University of Florida	April 2007
Faculty of the Year	Department of Mechanical Engineering Boston University	May 2006
Book of the Year	The Charles Stark Draper Laboratory, Inc.	April 2006
Outstanding Faculty of the Year	College of Engineering Boston University	May 2004
Faculty of the Year	Department of Mechanical Engineering Boston University	May 2002

REFERENCES

Available Upon Request