

# Yiyuan J. Zhao

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## Education

Ph.D.	Aeronautics and Astronautics,	Stanford University,	June 1989
M.S.	Aeronautics and Astronautics,	Stanford University,	April 1986
B.S.	Control Engineering,	Harbin Inst. of Tech., China,	July 1982

## Employment History

Professor:	University of Minnesota,	June 2005 – Present
	Department of Aerospace Engineering and Mechanics	
Associate Professor:	University of Minnesota,	July 1996 – May 2005
Assistant Professor:	University of Minnesota,	March 1990 – June 1996

## Awards

*Best Professor Award*, University of Minnesota, May 2006  
*Boeing – A. D. Welliver Faculty Summer Fellowship*, Summer 1999  
An eight-week program paid by Boeing for University faculty members to interact with Boeing engineers and scientists in various divisions.  
*Best 1996 AHS Paper Award*, “Optimal Trajectories for the Helicopter in OEI  
(Bay Area Chapter, with R. Chen) Terminal-Area Operations,” AGARD-CP-592, June 1997  
*Taylor Career Development Award* University of Minnesota, May 1996  
*Outstanding Teaching Award* University of Minnesota, May 1989

## Professional Society Memberships

Associate Fellow, American Institute of Aeronautics and Astronautics (AIAA)

## Current Areas of Research

Optimization of Algorithms and Applications. Dynamic system modeling, parameter optimization, dynamic optimization, solution algorithms, parallel and distributed optimization, optimization of complex systems, and vehicle motion optimization.

Automation of Multiple Vehicle Operation. Trajectory prediction, intelligent motion planning for autonomous operation, conflict detection and resolution, and unmanned aerial vehicles (UAVs).

Airborne Networks. Distributed decision-making across airborne networks. Benefit-based analysis and design of airborne networks for multiple vehicle communication, navigation, and surveillance.

## Referred Journal Publications

1. **Y. Zhao** and A. E. Bryson, Jr., "Optimal Paths Through Downbursts," *Journal of Guidance, Control, and Dynamics*, Vol. 13, Nov. 5, September-October, 1990, pp. 813-818.
2. **Y. Zhao** and A. E. Bryson, Jr., "Control of an Aircraft in Downbursts," *Journal of Guidance, Control, and Dynamics*, Vol. 13, No. 5, September-October, 1990, pp. 819-823.
3. **Y. Zhao**, A. E. Bryson, and R. Slattery, "Generalized Gradient Algorithm for Trajectory Optimization," *Journal of Guidance, Control, and Dynamics*, Vol. 13, No. 6, November-December, 1990, pp. 1166-1169.
4. **Y. Zhao** and A. E. Bryson, "Approach Guidance in a Downburst," *Journal of Guidance, Control, and Dynamics*, Vol. 15, No. 4, July-August, 1992, pp. 893-900.
5. **Y. Zhao**, "Solutions to Parameter Optimal Control," *Journal of Guidance, Control, and Dynamics*, Vol. 17, No. 2, March-April, 1994, pp. 414-416.
6. **Y. Zhao**, "Least Squares Optimal Linearization," *Journal of Guidance, Control, and Dynamics*, Vol. 17, No. 5, September-October, 1994, pp. 990-997.
7. **Y. Zhao** and R. T. N. Chen, "Critical Considerations for Helicopters During Runway Takeoffs," *Journal of Aircraft*, Vol. 32, No. 4, July-August, 1995, pp. 773-781.
8. **Y. Zhao**, A. Jhemi, and R. T. N. Chen, "Optimal VTOL Helicopter Operation in One Engine Failure," *Journal of Aircraft*, Vol. 33, No. 2, March-April, 1996, pp. 337-346.
9. **Y. Zhao** and R. A. Slattery, "Capture Conditions for Merging Trajectory Segments to Model Realistic Aircraft Descents," *Journal of Guidance, Control, and Dynamics*, Vol. 19, No. 2, March-April, 1996, pp. 453-460.
10. W. Vandersteel, **Y. Zhao**, and T. S. Lundgren, "Automating Movement of Freight," *Transportation Research Record*, No. 1602, Freight Transportation (Multimodal); Marine Transportation, 1997, pp. 71-76.
11. R. A. Slattery and **Y. Zhao**, "Trajectory Synthesis for Air Traffic Automation," *Journal of Guidance, Control, and Dynamics*, Vol. 20, No. 2, March-April, 1997, pp. 232-238.
12. M. Jackson, **Y. J. Zhao**, and R. A. Slattery, "Sensitivities of Trajectory Prediction in Air Traffic Management," *Journal of Guidance, Control, and Dynamics*, Vol. 22, No. 2, March-April, 1998, pp. 219-228.
13. T. S. Lundgren and **Y. J. Zhao**, "Aerodynamics of Electrically Driven Freight Pipeline System," *Journal of Transportation Engineering*, May-June, 2000, pp. 263-270.
14. V. Kuo and **Y. J. Zhao**, "Required Ranges for Conflict Resolutions in Air Traffic Management," *Journal of Guidance, Control, and Dynamics*, Vol. 24, No. 2, March-April, 2001, pp. 237-245.
15. E. B. Carlson and **Y. J. Zhao**, "Optimal Short Takeoff of Tiltrotor Aircraft in One Engine Failure," *Journal of Aircraft*, Vol. 39, No. 2, March-April, 2002, pp. 280-289.
16. E. B. Carlson and **Y. J. Zhao**, "Prediction of Tiltrotor Height-Velocity Diagrams Using Optimal Control Theory," *Journal of Aircraft*, Vol. 40, No. 5, Sept-Oct. 2003, pp. 896-905.

17. E. B. Carlson and **Y. J. Zhao**, "Optimal City-Center Takeoff Operation of Tiltrotor Aircraft in One Engine Failure," *Journal of Aerospace Engineering*, Vol. 17, No. 1, January 2004, pp. 26-39.
18. Ali A. Jhemi, E. B. Carlson, **Y. J. Zhao**, and R. T. N. Chen, "Optimization of Rotorcraft Flight Following Engine Failure," *Journal of the American Helicopter Society*, Vol. 49, No. 2, April 2004, pp. 117-126.
19. R. L. Ennis and **Y. J. Zhao**, "A Formal Approach to the Analysis of Aircraft Protected Zone," *Air Traffic Control Quarterly*, Vol. 12, No. 1, 2004, pp. 75-102.
20. M. X. Cheng and **Y. J. Zhao**, "Connectivity of Ad Hoc Networks for Advanced Air Traffic Management," *Journal of Aerospace Computing, Information, and Communication*, Vol. 1, No. 5, May 2004, pp. 225-238.
21. I. H. Yang and **Y. J. Zhao**, "Trajectory Planning for Autonomous Aerospace Vehicles Amid Known Obstacles and Conflicts," *Journal of Guidance, Control, and Dynamics*, Vol. 27, No. 6, Nov.-Dec., 2004, pp. 997-1108.
22. **Y. J. Zhao**, "Optimal Patterns of Glider Dynamic Soaring," *Optimal Control Applications and Methods*, Vol. 24, No. 2, 2004, pp. 67-89.
23. Y. C. Qi and **Y. J. Zhao**, "Energy-Efficient Trajectories of Unmanned Aerial Vehicles Flying Through Thermals," *Journal of Aerospace Engineering*, Vol. 18, No. 2, April 2005, pp. 84-92.
24. **Y. J. Zhao** and Y. C. Qi, "Minimal Fuel Powered Dynamic Soaring of Unmanned Aerial Vehicles Utilizing Wind Gradient," *Optimal Control Applications and Methods*, Vol. 25, 2004, pp. 211-233.
25. **Y. J. Zhao**, "Book Review: Optimal Control Theory for Applications," *International Journal of Robust and Nonlinear Control*, November 2005, pp. 903-904.
26. **Y. J. Zhao**, "Extracting Energy from Downdraft to Enhance Endurance of Uninhabited Aerial Vehicles," *Journal of Guidance, Control, and Dynamics*, Vol. 32, No. 4, July-August 2009, pp. 1124-1133.
27. J. Mueller, **Y. J. Zhao**, and W. L. Garrard, "Optimal Ascent Trajectories for Stratospheric Airships Using Wind Energy," *Journal of Guidance, Control, and Dynamics*, Vol. 32, No. 4, July-August 2009, pp. 1232-1245.
28. W. Guo, **Y. J. Zhao**, and B. Capozzi, "Optimal UAV Flights for Seeability and Endurance in Winds," *Journal of Aircraft*, Vol. 48, No. 1, Jan.-Feb. 2011, pp. 305-314.
29. Q. Zheng, **Y. J. Zhao**, and B. Capozzi, "Time-of-Arrival Taxi Conformance Monitoring for Surface Operations," *Journal of Guidance, Control, and Dynamics*, Vol. 34, No. 3, May-June 2011, pp. 750-760.
30. H. Chen, **Y. J. Zhao**, and C. Provan, "Multiple-Point Integrated Scheduling of Terminal Traffic," *Journal of Aircraft*, Vol. 48, No. 5, Sept-Oct., 2011, pp. 1646-1657.

## Other Publications

### Reports

- Robert T. N. Chen and Y. Zhao, "Optimal Trajectories for the Helicopter in One-Engine-Inoperative Terminal-Area Operations," NASA TM 110400, May 1996.

- Y. Zhao and T. S. Lundgren, “Dynamics and Stability of Capsules in Pipeline Transportation,” Minnesota Dept. of Transportation, Office of Research Administration, 200 Ford Building MS 330, 117 Univ. Ave., St. Paul, MN 55155, Report No. 96-17.
- Y. Zhao, T. S. Lundgren, and John M. Sampson, “Analysis of Electrical Freight Pipeline System,” Minnesota Dept. of Transportation, Office of Research Administration, 200 Ford Building MS 330, 117 Univ. Ave., St. Paul, MN 55155, March, 2000.

Conference Papers Appearing in Printed Proceedings (Reviewed)

- Y. Zhao and A. E. Bryson, “Optimal Paths Through Downbursts,” *Proceedings of the ALAA Guidance, Navigation, and Control Conference*, Boston, Massachusetts, pp. 1139-1149, August 12-14, 1989. *ALAA Paper No. 89-3561*.
- Y. Zhao, A. E. Bryson, and R. A. Slattery, “A Generalized Gradient Algorithm for Dynamic Optimization,” *Proceedings of the ALAA Guidance, Navigation, and Control Conference*, Boston, Massachusetts, pp. 1570-1580, August 12-14, 1989, *ALAA Paper No. 89-3618*.
- Y. Zhao and A. E. Bryson, Jr., “Simple Analyses of Paths Through Windshears and Downdrafts,” *ALAA 28<sup>th</sup> Aerospace Sciences Meeting*, Reno, Nevada, January 1990. *ALAA Paper No. 90-0222*.
- Y. Zhao and A. E. Bryson, Jr., “A Simplified Ring-Vortex Downburst Model,” *ALAA 28<sup>th</sup> Aerospace Sciences Meeting*, Reno, Nevada, January 1990. *ALAA Paper No. 90-0580*.
- Y. Zhao and A. E. Bryson, “State Inequality Constraint in the Design of Open and Closed Loop Control Systems,” *Proceedings of the ALAA Guidance, Navigation, and Control Conference*, New Orleans, Louisiana, pp. 453-457, August 12-14, 1991. *ALAA Paper NO. 91-2648*.
- Y. Zhao, “A Classification of Trajectory Optimization Algorithms,” *Proceedings of the ALAA Guidance, Navigation, and Control Conference*, New Orleans, Louisiana, pp. 390-394, August 12-14, 1991. *ALAA Paper No. 91-2724*.
- Y. Zhao, “Concepts of Least Squares Optimal Linearizations,” *Proceedings of the ALAA Guidance, Navigation, and Control Conference*, Hilton Head Island, South Carolina, pp. 1186-1195, August 10-12, 1992. *ALAA Paper No. 92-4554*.
- Y. Zhao and W. Garrard, “Piecewise-Constant Guidance for Aeroassisted Maneuvers,” *Proceedings of the ALAA Atmospheric Flight Mechanics Conference*, Hilton Head Island, South Carolina, pp. 709-714, August 10-12, 1992. *ALAA Paper No. 92-4643*.
- V. Sharma and Y. Zhao, “Dynamic Optimal Linearization of Nonlinear Systems,” *Proceedings of the American Control Conference*, San Francisco, California, pp. 1196-1197, June 2-4, 1993.
- Y. Zhao and R. T. N. Chen, “Optimal Category-A Helicopter Takeoff from a Runway,” *Proceedings of the ALAA Guidance, Navigation, and Control Conference*, Scottsdale, Arizona, pp. 1366-1376, August 1-2, 1994. *ALAA Paper No. 94-3695*.
- V. Sharma, Y. Zhao, R. T. N. Chen, and W. S. Hindson, “Optimal OEI Clear Heliport Operation of a Multiengine Helicopter,” *Proceedings of the American Helicopter Society 51<sup>st</sup> Annual Forum*, Fort Worth, Texas, May 9-11, 1995.

- Y. Zhao, A. Jhemi, and R. T. N. Chen, "Optimal VTOL Operation of a Multiengine Helicopter in the Event of One Engine Failure," *Proceedings of the AIAA Guidance, Navigation, and Control Conference*, Baltimore, Maryland, pp. 38-47, August 7-9, 1995. *AIAA Paper No. 95-3178*.
- Y. Zhao, M. Jackson, and R. A. Slattery, "Aircraft Trajectory Sensitivity in Air Traffic Control Automation and Flight Management," *Proceedings of the AIAA Guidance, Navigation, and Control Conference*, Baltimore, Maryland, pp. 1467-1473, August 7-9, 1995. *AIAA Paper No. 95-3332*.
- Y. Zhao and R. A. Slattery, "Capture Conditions in Center Trajectory Synthesis for Center-TRACON Automation System," *Proceedings of the AIAA Guidance, Navigation, and Control Conference*, Baltimore, Maryland, pp. 1749-1757, August 7-9, 1995. *AIAA Paper No. 95-3365*.
- Ali Jhemi, Y. Zhao, and R. T. N. Chen, "Real-Time Generation of Optimal Helicopter Trajectories for On-board Display," presented at the *34<sup>th</sup> AIAA Aerospace Sciences Meeting and Exhibit*, Reno, Nevada, January 1996, *AIAA Paper No. 96-0792*.
- R. A. Slattery and Y. Zhao, "Trajectory Synthesis via Parameter Optimal Control for Automated Air Traffic Control," presented at the *34<sup>th</sup> AIAA Aerospace Sciences Meeting and Exhibit*, Reno, Nevada, January 15-18, 1996. *AIAA Paper No. 96-0793*.
- M. Jackson, Y. Zhao, and R. A. Slattery, "Effects of Modeling Errors on Trajectory Predictions in Air Traffic Control Automation," presented at the AIAA Guidance, Navigation, and Control Conference, San Diego, California, July 29-31, 1996. *AIAA Paper No. 96-3721*.
- Y. Zhao and T. S. Lundgren, "Dynamics and Stability of a Freight Pipeline System," presented at the Annual Minnesota Transportation Conference, May 1996.
- R. T. N. Chen and Y. Zhao, "Optimal Trajectories for the Helicopter in One-Engine-Inoperative Terminal-Area Operations," presented at the Flight Vehicle Integration Panel Symposium, Ottawa, Canada, 27-30 May 1996. AGARD-CP-592.
- V. Sharma, Y. Zhao, and R. T. N. Chen. "Optimal Sideways Operation of a Category-A Helicopter from an Elevated Helipad," *Proceedings of the American Helicopter Society 52<sup>nd</sup> Annual Forum*, Washington, D. C., June 4-6, 1996.
- Y. Zhao, "Closed-Loop Sensitivities of Flight Trajectories," presented at the Northwestern Polytechnic University/AIAA Atmospheric Flight Mechanics Conference, June 11-14, 1996, Xian, China.
- T. S. Lundgren and Y. Zhao, "Characteristics of a Pipeline Transportation System," presented at the International Symposium on Lubricated Transport of Viscous Materials, January 7-10, 1997, Tobago, West Indies.
- Y. J. Zhao and R. Schultz, "Deterministic Resolution of Two Aircraft Conflict in Free Flight," AIAA Guidance and Control Conference, New Orleans, August 11-13, 1997.
- H. Chen and Y. J. Zhao, "A New Queuing Model for Aircraft Landing Process," AIAA Guidance and Control Conference, New Orleans, August 11-13, 1997.
- R. Schultz, D. Shanner, and Y. J. Zhao, "Free Flight Concepts," AIAA Guidance and Control Conference, New Orleans, August 11-13, 1997.

- Y. J. Zhao, C. Haissig, and M. Hoffman, “Analysis of Pilot Intent in Air Traffic Management,” *Proceedings of the American Control Conference*, Philadelphia, June 24-26, 1998.
- V. Kuo and Y. J. Zhao, “Conflict Resolution and Alert Zone Estimation in Air Traffic Management,” presented at the AIAA Guidance, Navigation, and Control Conference, August 9-11, 1999, Portland, Oregon.
- E. Carlson, Y. J. Zhao, and R. T. N. Chen, “Optimal Tiltrotor Aircraft Runway Operations in the Event of One Engine Failure,” presented at the AIAA Guidance, Navigation, and Control Conference, August 9-11, 1999, Portland, Oregon.
- Y. J. Zhao, E. B. Carlson, A. A. Jhemi, and R. T. N. Chen, “Optimization of Rotorcraft Flight in Engine Failure,” presented at the American Helicopter Society 56 Forum, May 2-4, Virginia Beach, Virginia.
- J. Plaettner-Hochwarth, Y. J. Zhao, and J. Robinson, “Comprehensive Dynamic Simulation of Air Traffic System,” presented at the AIAA Guidance, Navigation, and Control Conference, August 14-17, 2000, Denver, Colorado.
- Y. J. Zhao and D. Rock, “Alerting Functionality for UAVs,” Presented at the First AIAA UAV Conference, Portsmouth, VA, May 2002.
- I. H. Yang and Y. J. Zhao, “Trajectory Planning for UAVs,” Presented at the First AIAA UAV Conference, Portsmouth, VA, May 2002.
- Y. J. Zhao and D. Rock, “Fundamental Principles of Alerting Algorithm Design for Rotorcraft Formation Flight,” presented at the AIAA Guidance & Control Conference, Monterey, CA, August 2002.
- Y. J. Zhao, “Estimation of Trajectory Predictions Uncertainties for Advanced Air Traffic Management,” Presented at the AIAA ATIO Conference, Los Angeles, CA, Oct. 1, 2002.
- Y. J. Zhao, “Fundamental Principles of Alerting Algorithm Design for UAVs,” Presented at the Technical Analysis & Application Center Conference 2002, Santa Fe, NM, Oct. 28-30, 2002.
- Y. J. Zhao and Y. Celia Qi, “Minimum Thrust Trajectories of UAVs in Wind Gradients,” Presented at the 2<sup>nd</sup> AIAA UAV Systems Conference, San Diego, Sept. 15-18, 2003.
- M. X. Cheng and Y. J. Zhao, “An Airborne Wireless Network for Enhanced Situational Awareness,” Presented at the 2<sup>nd</sup> AIAA UAV Systems Conference, San Diego, Sept. 15-18, 2003.
- R. L. Ennis and Y. J. Zhao, “Characterization of Aircraft Protected Zones,” Presented at the 3<sup>rd</sup> AIAA ATIO Conference, Denver, CO, Nov. 17-19, 2003.
- Y. J. Zhao and M. X. Cheng, “Transmission Protocols and Information Reachability of Ad Hoc Airborne Networks,” presented at the 4<sup>th</sup> Integrated CNS Conference, April 23-26, 2004, Fairfax, Virginia.
- I. H. Yang and Y. J. Zhao, “An Efficient Algorithm for Trajectory Smoothing of Unmanned Aerial Vehicles through Specified Waypoints,” presented at the AIAA 3<sup>rd</sup> “Unmanned Unlimited” Technical Conference, Workshop, and Exhibit, AIAA-2004-6525, September 20-23, 2004, Chicago, Illinois.

- Y. J. Zhao, W. L. Garrard, and J. Mueller, “Benefits of Trajectory Optimization in Airship Flight,” presented at the AIAA 3<sup>rd</sup> “Unmanned Unlimited” Technical Conference, Workshop, and Exhibit, AIAA-2004-6527, September 20-23, 2004, Chicago, Illinois.
- J. Mueller and Y. J. Zhao, “Aerodynamic Modeling and Control Law Design for a High Altitude Airship,” presented at the AIAA 3<sup>rd</sup> “Unmanned Unlimited” Technical Conference, Workshop, and Exhibit, AIAA-2004-6479, September 20-23, 2004, Chicago, Illinois.
- R. L. Ennis and Y. J. Zhao, “Defining Appropriate Inter-Aircraft Separations,” presented at the AIAA 4<sup>th</sup> Aviation Technology, Integration and Operations (ATIO) Forum, AIAA-2004-6203, September 20-23, 2004, Chicago, Illinois.
- Y. J. Zhao and Y. Wang, “Adjustable Range Broadcast for Desired Airborne Network Connectivity,” presented at the 5<sup>th</sup> Integrated Communication, Navigation & Surveillance (CNS) Conference and Workshop, Fairfax, Virginia, May 2-5, 2005.
- Y. Wang and Y. J. Zhao, “Integration of Airport Surface Communication Systems,” presented at the 5<sup>th</sup> Integrated Communication, Navigation & Surveillance (CNS) Conference and Workshop, Fairfax, Virginia, May 2-5, 2005.
- Y. J. Zhao, “Taking Advantage of Wind Energy in UAV Operations,” presented at the AIAA Infotech@Aerospace Conference, Arlington, VA, September 26-29, 2005.
- I. H. Yang and Y. J. Zhao, “Practical Strategies of Wind Energy Utilization in UAV Flights,” presented at the AIAA Infotech@Aerospace Conference, Arlington, VA September 26-29, 2005.
- Y. Wang and Y. J. Zhao, “Systematic Design of Airborne Networks for Aviation,” to be presented at the 2006 IEEE Aerospace Conference, February 2006.

#### Invited Lectures and Papers

- Y. Zhao and A. E. Bryson, Jr., “Aircraft Control in a Downburst on Takeoff and Landing,” *The 29<sup>th</sup> IEEE Conference on Decision and Control*, Honolulu, Dec. 1990.
- Y. Zhao, “Sensitivities of Trajectory Calculations in Air Traffic Control Automation,” *Trajectory Sensitivity Workshop*, NASA Ames Research Center, November 1994.
- R. A. Slattery and Y. Zhao, “En-Route Trajectory Synthesis for Automated Air Traffic Control,” *American Control Conference*, June 1995. Seattle.

#### **Student Research Supervision**

- Have supervised one post-doctoral associate, 9 doctoral dissertations, 12 Masters thesis, and 8 undergraduate research projects.
- Currently advising 3 Ph.D. students.

#### **Course Teaching**

- Have taught a wide range of undergraduate and graduate courses in dynamics, systems, and optimization.

## **Consulting**

- Honeywell (1996-1998, 2006-2007), Boeing (1999-2001, 2004-2006), Metron Aviation (2003), and Princeton Satellite Systems (2004-2005).