Brual Shah

Center for Advanced Manufacturing, University of Southern California, LA, CA
http://brual.info | brualsha@usc.edu | 213.280.7265

http://linkedin.com/in/brual

CAREER GOALS

Pursue a career in the field of robotics with specialization in:

- Developing Smart robotic assistants for manufacturing automation
- Physics-based motion planning algorithms for unmanned systems
- Intelligent decision-making algorithms for realizing operations of autonomous systems
- Machine learning-based approaches to enhance performance of autonomous robots
- Human-robot collaboration

SUMMARY

Have significant experience in robotics research, algorithm development, and project management. Designed, developed, and experimentally evaluated motion planning algorithms for autonomous systems operating in the real world.

EDUCATION

MECHANICAL ENGINEERING | Doctor of Philosophy (Ph.D)

Fall 2013 – Summer 2016 | University of Maryland, College Park, MD

- Dissertation Topic: Planning for Autonomous Operation of Unmanned Sea Surface Vehicles (USVs)
- Advisor: Professor Satyandra K. Gupta

TELECOMMUNICATION ENGINEERING | Master of Science (M.S)

Fall 2011 – Spring 2013 | University of Maryland, College Park, MD

ELECTRONICS AND TELECOMMUNICATION ENGINEERING | Bachelor of Science (B.S)

Fall 2007 - Spring 2011 | K.J. Somaiya College of Engineering, Vidyavihar, University of Mumbai, India

RESEARCH AND TEACHING EXPERIENCE

CENTER OF ADVANCED MANUFACTURING | Research Associate

Summer 2017 – Current | University of Southern California, Los Angeles, CA

- Developed a context-dependent point to point trajectory planner for high DOF robotic manipulator that dynamically selects the heuristic for search
- Developed a tool path planner, setup planner, parameter learning algorithm, and part placement algorithm for robotic finishing system
- Developed a 9DOF planner for autonomous operation of Mobile Manipulator by combining graph search and optimization-based motion planning algorithms
- Assisted in developing a composite layup cell that consists of 3 manipulator robots used for laying up prepreg sheets on a complex mold and generating carbon fiber parts

MARYLAND ROBOTICS CENTER | Postdoctoral Research Associate

Fall 2016 – Summer 2017 | University of Maryland, College Park, MD

- Developed a dynamics-aware reactive planner for Unmanned Ground Vehicles (UGV) for avoiding dynamic obstacles while operating on uneven terrains
- Developed a simulation environment for hybrid (human-robot collaboration) work cell assembly operating using Gazebo and Robot Operating System (ROS)
- Developed a framework to proactively handle contingencies in hybrid work cell assembly operation

MARYLAND ROBOTICS CENTER | Graduate Research Assistant

Spring 2012 – Summer 2016 | University of Maryland, College Park, MD

- Developed a real-time risk and congestion-aware trajectory planners (RCAP & A-RCAP) for operation of Unmanned Surface Vehicles (USV) in an environment with congested civilian traffic.

- Developed a long-distance path planner for USV operating in complex and large marine environment
- Developed an energy-efficient trajectory planner for unmanned vehicles operating in environment with significant flow-fields (e.g. ocean currents, winds, etc.)
- Developed and deployed planning algorithms for approach, follow and COLREGs behavior of USV.

HYPERION TECHNOLOGIES | Software Engineering Intern
Summer 2015| College Park, MD

- Developed a framework that converts the nautical chart data of the marine environment to quadtree data structure
- Developed an interface for the human operator to monitor and alter the paths produced planners in real-time

DEPT. OF MECHANICAL ENGINEERING | Teaching Assistant
Fall 2014 & Fall 2015| University of Maryland, College Park, MD

- Course: Bio-Inspired Robotics
- Assisted undergraduate students in designing the mechanical and electrical components of their bio-inspired robots, and programming the walking gait of the robots using Arduino.

PUBLICATIONS

JOURNAL ARTICLES

- **B. C. Shah** , and S.K. Gupta. Long distance path planning for unmanned surface vehicles in complex marine environment. *IEEE Journal of Oceanic Engineering* , doi: 10.1109/JOE.2019.2909508, 2019.
- S. Shriyam, **B. C. Shah** , and S.K. Gupta. Decomposition of Collaborative Surveillance Tasks for Execution in Marine Environments by a Team of Unmanned Surface Vehicles. *ASME Journal of Mechanisms and Robotics* , 10(2):025007-7, 2018.
- **B. C. Shah** , P. Švec, I.R. Bertaska, W. Klinger, A. J. Sinisterra, K. von Ellenrieder, M. Dhanak, and S.K. Gupta. Resolution-Adaptive Risk-Aware Trajectory Planning for Surface Vehicles Operating in Congested Civilian Traffic. *Autonomous Robots* , 40(7): 1139–1163, 2016.
- I.R. Bertaska, **B. C. Shah** , K. von Ellenrieder, P. Svec, W. Klinger, A.J. Sinisterra, M. Dhanak, and S.K. Gupta. Experimental evaluation of automatically-generated behaviors for USV operations. *Ocean Engineering* , 106:496-514, 2015.
- P. Švec, A. Thakur, E. Raboin, **B. C. Shah** and S.K. Gupta. Target Following with Motion Prediction for Unmanned Surface Vehicle Operating in Cluttered Environments. *Autonomous Robots* , 36(4): 383-405, 2014.

FULL PAPER REFEREED PUBLICATIONS IN CONFERENCES AND WORKSHOPS

- P. Rajendran, S. Thakar, A.M. Kabir, **B. C. Shah** , and S.K. Gupta. Context-Dependent Search for Generating Paths for Redundant Manipulators in Cluttered Environments. *IEEE International Conference on Intelligent Robots and Systems (IROS)* , Macau, China, November 2019.
- S. Thakar, A. Kabir, P. M. Bhatt, R. K. Malhan, P. Rajendran, **B. C. Shah** and S. K. Gupta. Task assignment and motion planning for bi-manual mobile manipulation. *IEEE International Conference on Automation Science and Engineering (CASE)* , Vancouver, Canada, August 2019.
- P. M. Bhatt, A. M. Kabir, R. K. Malhan, A. V. Shembekar, **B. C. Shah** , and S. K. Gupta. Concurrent design of tool-paths and impedance controllers for performing area coverage operations in manufacturing applications under uncertainty. *IEEE International Conference on Automation Science and Engineering (CASE)* , Vancouver, Canada, August 2019.
- R.K. Malhan, A.M. Kabir, **B. C. Shah** , T. Centea, and S.K. Gupta. Determining feasible robot placements in robotic cells for composite prepreg sheet layup. *ASME Manufacturing Science and Engineering Conference (MSEC)* , Erie, PA, June 2019.
- P.M. Bhatt, A.M. Kabir, R.K. Malhan, **B. C. Shah** , A. V. Shembekar, Y.J. Yoon, and S.K. Gupta. A robotic cell for multi-resolution additive manufacturing. *IEEE International Conference on Robotics and Automation (ICRA)* , Montreal, Canada, May 2019.
- R. K. Malhan, A. M. Kabir, **B. C. Shah** , and S. K. Gupta. Identifying feasible workpiece placement with respect to redundant manipulator for complex manufacturing tasks. *IEEE International Conference on Robotics and Automation (ICRA)* , Montreal, Canada, May 2019.
- A. M. Kabir, A. Kanyuck, R. K. Malhan, A. V. Shembekar, S. Thakar, **B. C. Shah** , and S. K. Gupta. Generation of synchronized configuration space trajectories of multi-robot systems. *IEEE International Conference on Robotics and Automation (ICRA)* , Montreal, Canada, May 2019.
- P. Rajendran, T. Moscicki, J. Wampler, **B. C. Shah** , K. von Ellenrieder and S. K. Gupta. Wave-Aware Trajectory Planning for Unmanned Surface Vehicles Operating in Congested Environments. *IEEE International Symposium on Safety, Security, and Rescue Robotics (SSRR)* , Philadelphia, PA, 2018.

- A. M. Kabir, **B. C. Shah** , and S. K. Gupta. Trajectory Planning for Manipulators Operating in Confined Workspaces. *IEEE International Conference on Automation Science and Engineering (CASE)* , Munich, Germany, Aug 2018.
- R. K. Malhan, A. M. Kabir, A. V. Shembekar, **B. C. Shah** , T. Centea, and S. K. Gupta. Hybrid Cells for Multi-Layer Prepreg Composite Sheet Layup. *IEEE International Conference on Automation Science and Engineering (CASE)* , Munich, Germany, Aug 2018.
- S. Thakar, L. Fang, **B. C. Shah** , and S. K. Gupta. Towards Time-Optimal Trajectory Planning for Pick-and-Transport Operation with a Mobile Manipulator. *IEEE International Conference on Automation Science and Engineering (CASE)* , Munich, Germany, Aug 2018.
- A. M. Kabir, A. V. Shembekar, R. K. Malhan, R. S. Aggarwal, J. D. Langsfeld, **B. C. Shah** , and S. K. Gupta. Robotic finishing of interior regions of geometrically complex parts. *ASME 13th Manufacturing Science and Engineering Conference (MSEC)* , College Station, Texas, USA, June 2018.
- R. K. Malhan, Y. Shahapurkar, A. M. Kabir, **B. C. Shah** , and S. K. Gupta. Integrating impedance control and learning based search scheme for robotic assemblies under uncertainty. *ASME 13th Manufacturing Science and Engineering Conference (MSEC)* , College Station, Texas, USA, June 2018.
- R. K. Malhan, A. M. Kabir, **B. C. Shah** , T. Centea, and S. K. Gupta. Automated Prepreg Sheet Placement Using Collaborative Robotics. *Society for the Advancement of Material and Process Engineering (SAMPE) Spring Technical Conference and Exhibition* , Long Beach, California, USA, May 2018.
- S. Shriyam, **B. C. Shah** , and S. K. Gupta. On-Line Task Decomposition for Collaborative Surveillance of Marine Environment by a Team of Unmanned Surface Vehicles. *ASME Mechanism and Robotics Conference* , Cleveland, OH, August 2017.
- P. Rajendran, **B. C. Shah** , and S.K. Gupta. Dynamics-Aware Reactive Planning for Unmanned Ground Vehicles to Avoid Collisions with Dynamic Obstacles on Uneven Terrains. *ICAPS 2016 Workshop on Planning and Robotics (PlanRob)* , Pittsburgh, PA, USA, June 18 - 23, 2017.
- **B. C. Shah** , and S. K. Gupta. Speeding up A* search on visibility graphs defined over quadtrees to enable long distance path planning for unmanned surface vehicles. *International Conference on Automated Planning and Scheduling (ICAPS' 16)* , London, UK, June 12 - 17, 2016.
- **B. C. Shah** , P. Švec, A. Thakur, and S.K. Gupta. Path Planning for Unmanned Vehicles Operating in Time-Varying Flow Fields. *ICAPS 2016 Workshop on Planning and Robotics (PlanRob)* , London, UK, June 12 - 17, 2016.
- **B. C. Shah** , P. Švec, I. R. Bertaska, W. Klinger, A. J. Sinisterra, K. von Ellenrieder, M. Dhanak, and S. K. Gupta. Trajectory Planning with Adaptive Control Primitives for Autonomous Surface Vehicles Operating in Congested Civilian Traffic. *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS '14)* , Chicago, IL, USA, September 14-18, 2014.
- P. Švec, **B. C. Shah** , I.R. Bertaska, W. Klinger, A. J. Sinisterra, K. von Ellenrieder, M. Dhanak, and S.K. Gupta. Adaptive sampling based COLREGS-compliant obstacle avoidance for autonomous surface vehicles. *ICRA 2014 Workshop on Persistent Autonomy for Marine Robotics (PAMR '14)* , Hong Kong, China, June 2014.
- P. Švec, **B. C. Shah** , I. R. Bertaska, J. Alvarez, A. J. Sinisterra, K. von Ellenrieder, M. Dhanak, and S. K. Gupta. Dynamics-Aware Target Following for an Autonomous Surface Vehicle Operating under COLREGs in Civilian Traffic. *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS '13)* , Tokyo, Japan, November 3-7, 2013.
- I. B. Bertaska, J. Alvarez, A. J. Sinisterra, K. Ellenrieder, M. Dhanak, **B. C. Shah** , P. Švec, and S. K. Gupta. Experimental Evaluation of Approach Behavior for Autonomous Surface Vehicles. *6th Annual Dynamic Systems and Control Conference (DSCC '13)* , Stanford University, Palo Alto, CA, USA, October 21-23, 2013.
- P. Švec, A. Thakur, **B. C. Shah** , and S.K. Gupta. USV trajectory planning for time varying motion goals in an environment with obstacles. *ASME Mechanism and Robotics Conference* , Chicago, IL, August 2012.

AWARDS

- First place in Aerodef Poster Challenge at Aerodef Manufacturing Conference, Long Beach, CA. May 2019.
- First place in Best Paper Award at IEEE International Symposium on Safety, Security, and Rescue Robotics (SSRR) Conference in 2018.
- Third place in Best Paper Award at ASME 13th Manufacturing Science and Engineering Conference (MSEC), 2018.
- Judge's choice Award for poster at AST-NSF-ASME-SME Workshop on Challenges in Representing Manufacturing Processes for Systemic Sustainability Assessments at ASME 13th Manufacturing Science and Engineering Conference (MSEC), 2018.
- First place in Agile Robotics for Industrial Automation Competition (ARIAC) organized by National Institute of Standards and Technology (NIST) in 2017.
- Finalist in KUKA Innovation Award Competition in 2017.

PATENTS

- R. K. Malhan, T. Centea, S. K. Gupta, A. M. Kabir, **B. C. Shah** , and A. V. Shembekar, "Hybrid Formation of Multi-Layer Prepreg Composite Sheet Layup", U.S. Provisional Patent 62/715,497. Filled on August 7, 2018.
- S. K. Gupta, A. M. Kabir, and **B. C. Shah** , "Setup Planning, Trajectory Planning, and Parameter Selection for Robotic Finishing", U.S. Provisional Patent 62/661,441, Filled on April 23, 2018.
- **B. C. Shah** , P. Švec, and S. K. Gupta, "Surface vehicle trajectory planning systems, devices, and methods", U.S. Patent 10,019,006. Awarded on July 10, 2018.

LEADERSHIP

ROBOCON CLUB | Team Leader

Fall 2010 - Spring 2011 | K.J. Somaiya College of Engineering, Vidyavihar, University of Mumbai, India

- Led the team of 20 members who participated in national robotics competition named Robocon for the first time representing our college.
- Achieved 21st position out of 53 teams who participated across the country.
- Designed and built a human driven robot and an autonomous Line-Follower Robot to perform designed task of the competition.

COMPUTER SKILLS

SOFTWARE

Libraries:
Robot Operating System (ROS) • Gazebo •Open Scene Graph (OSG) • OpenCV • Lightweight Communication & Marshaling (LCM)
Tools:
Git • Microsoft Visual Studio • Eclipse
Operating System:
Windows • Linux

PROGRAMMING

Over 5000 lines:
C++ • Python • Matlab • LaTeX
Familiar:
C • Java • Assembly

PROFESSIONAL MEMBERSHIP

- Institute of Electrical and Electronics Engineers (IEEE) since June 2013.
- American Society of Mechanical Engineers (ASME) since June 2013

REFERENCES

SATYANDRA K. GUPTA
Smith International Professor
Aerospace and Mechanical Engineering Department
Director,Realization of Robotic Systems Laboratory
Viterbi School of Engineering
University of Southern California, LA, CA 90089
Email: skgupta@usc.edu
Phone: (213) 740-0491

PETR ŠVEC
Senior Research Scientist
Apple Inc.
One Infinite Loop
Cupertino, CA 95014
Email: psvec@apple.com

KARL VON ELLENDRIEDER
Professor
Libera Università di Bolzano
Facoltà di Scienze e Tecnologie
Piazza Università 5
39100 Bolzano, Italy
Email: karl.vonellenrieder@unibz.it
Phone: +39-0471-017172

CARLOS MORATO
Principal Scientist Core-AI and Machine Learning
Microsoft
Seattle, WA
Email: carlos.morato@microsoft.com