Deepak Raina

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https://deepakraina99.github.io/

EXPERIENCE

Johns Hopkins University, Maryland, USA	Jan 2024 – Present
Post-doctoral Fellow	
Purdue University, Indiana, USA	July 2023 – Dec 2023
Post-doctoral Fellow	
Purdue University, Indiana, USA	Jan 2022 – June 2023
SERB-Overseas Visiting Doctoral Fellow	
TCS Research and Innovation Lab, Delhi, India	Dec 2017 – July 2019
Researcher	

EDUCATION

Indian Institute of Technology, Delhi	July 2019 – Sep 2023
Ph.D. in Mechanical Engineering (Research: Robotics and AI)	*GPA: 9/10*
Indian Institute of Technology, Jodhpur	July 2015 – June 2017
Master of Technology in Mechanical Engineering (Research: Space Robotics)	*GPA: 9.24/10*
Maharishi Markandeshwar University, Ambala	June 2011 – May 2015
Bachelor of Technology in Mechanical Engineering	*GPA:9/10*

RESEARCH INTERESTS

Robotic manipulation, Computer Vision, Machine Learning, Deep Learning, Motion-planning, Reinforcement Learning, Tele-robotics, Vision-guided Robotics, Space Robotics, Vehicle Dynamics

SKILLS

- **Programming Languages**: Python, C++, MATLAB, HTML

- **Tools**: ROS2, ROS, MuJoCo, Pybullet, Gazebo, MoveIt!, Pytorch, Tensorflow, OpenCV, SciPy, Pandas, Qt-creator

- **Hardware**: Sawyer robots, Universal robots (UR10, UR5), RG2 gripper, Intel RealSense camera, Haptic devices

ACADEMIC EXPERIENCE

Post-doctoral Fellow   July 2023 - Dec 2023
Purdue University, USA

- Developed a coaching framework to provide real-time feedback from expert sonongraphers, enhancing the learning rate of robotic ultrasound procedure by 32.8%.
- Lead collaborator in drafting proposal for submission to joint funding call by US-NSF and India-DST.
- Led a human trials review board application to Purdue University for robotic ultrasound.
- Secured funding of 50K USD for a project on bi-directional coaching of dexterous procedures.

Visiting Doctoral Research Fellow   Jan 2022 - July 2023
Purdue University, USA

- **Autonomous robotic manipulation of ultrasound probe**:
  - Formulated a Bayesian Optimization (BO)-based search strategy, utilizing *domain expertise* to efficiently locate high-quality images within the scanning region, eliminating the need for thorough scanning.
  - Proposed modeling expert's knowledge in the form of Guassian Process priors and kernels, gleaned from expert's demonstrations of high-quality probing poses.
  - Achieved 50-60% increase in sample efficiency and 25-30% increase in optimization speed.
- **Quality assessment of ultrasound images**:
  - Developed a supervised deep learning model using multi-scale feature extraction and second-order pooling.
  - Developed an unsupervised deep learning model using clustering layer in variational auto-encoder.
  - Achieved accuracy of 93% and 78% for supervised and unsupervised models, surpassing SOTA by 3-14%.

- **Robotic gripper with gel dispenser**:
  - ∗ Developed a deep learning model to detect the gel from real-time images acquired using an onboard camera
  - ∗ A motorized mechanism is developed, which uses this feedback and dispenses the gel
  - ∗ Increased the acquired image quality by 18.6% and reduces the procedure time by 37%.

- **Doctoral Research Fellow**   July 2020 - Dec 2021
  Indian Institute of Technology, Delhi
  - **Telerobotic ultrasound system (Video)**:
    - ∗ Developed the control architecture to teleoperate the ultrasound probe attached to the robotic arm
    - ∗ System performance analysis through 21 human trials at All India Institute of Medical Sciences, Delhi
    - ∗ Results demonstrated a P-value of < 0.05 on comparing tele-robotic and manual ultrasound images, gradual improvement of NASA-TLX test parameters, and 0.95 value of reliability index for questionnaire survey.

INDUSTRIAL EXPERIENCE

- **TCS Robotics Research and Innovation Lab**   Delhi, India
  Researcher - Robotics group   *Dec. 2017 - July 2019*
  - **Robotic packing of Long Distance Carriers (LDCs) (Video)**:
    - ∗ Designed new industrial level system to automatically and optimally load parcels in LDC's.
    - ∗ Developed collision-free motion planning module for picking parcels from conveyor and placing in LDC's.
    - ∗ Helped achieve target filling rate of 12 seconds per LDC.
  - **Palletizer - Automated Truck Loading System (ATLS)**:
    - ∗ Designed GUI-based system having a UR-10 manipulator that can load heterogeneous boxes on a pallet.
    - ∗ Increased system throughput by directly planning motions using UR-driver by surpassing ROS-MoveIt.
    - ∗ Successfully achieved target output of 12 seconds per pick and place of the box.

RELEVANT COURSE-WORK

Robotics, AI for Cognitive Robot Intelligence, Reinforcement Learning, Computer Vision, Machine Learning, Linear-Systems Theory, Linear Algebra, Multibody Dynamics, Computer-Aided Design, Finite Element Method, Vehicle Dynamics

GRANTS

- **Purdue University Internal Grants (2023-2025)**: Bidirectional coaching for corobotic assistance with invasive and non-invasive medical procedures. Funding: USD 50K. Role: Student Lead

- **Department of Science and Technology (2019-2024)**: Technology Innovation Hub on Collaborative Robotics at IIT Delhi. Funding: Rs. 115 Crore. Role: Student Lead

ACHIEVEMENTS

- **Malone Postdoctoral Fellowship (2023-2024)**: Among 2 students to be selected across the globe for a Malone postdoctoral fellowship at Johns Hopkins University.

- **SERB - Overseas Visiting Doctoral Fellowship (2022-2023)**: Among 25 Ph.D. students to be selected across the country to spend 1.5 years at Purdue University, USA.

- **DST - AWSAR 2022 Award**: Doctoral research story distinguished as one of the nation's top 100 scientific research stories

- **IEEE RAS Travel Grant**: Awarded for supporting my travel to ICRA 2023 in London (UK)

- **Purdue Dean's Travel Grant**: Awarded for supporting my travel to ISMR 2023 in Georgia (USA)

- **Runner-up International Robot Design Competition Award (2021)**: Awarded to our Telerobotic Ultrasound system at ICSR 2021 Robot Design Competition for the COVID-19 innovative response.

- **Director's Honorarium (2021)**: Awarded by Director of IIT Delhi for my efforts in establishing the Technology Innovation Hub (TIH) on Collaborative robotics (Cobotics) at IIT Delhi.

- **Prime Minister's Research Fellowship (2019-2023)**: Among 10 students to be selected across country in Mechanical Engineering. This fellowship is awarded by Ministry of Education (MoE) for persuing Ph.D. at IITs

- **Dassault Systèmes Design Award (2014)**: Awarded 2nd prize in design of human-powered vehicle competition organized by ASME at IIT Delhi.

- **Indira Gandhi Merit Scholarship (2011-2015)**: Awarded by Director of Higher Education for securing 7th rank in 12th state board exams.

PUBLICATIONS

- **Conferences**

  - Robotic Sonographer: Autonomous Robotic Ultrasound using Domain Expertise in Bayesian Optimization, [Paper]. **D. Raina**, S.H. Chandrashekhara, R. Voyles, J. Wachs, S.K. Saha. IEEE International Conference on Robotics and Automation (**ICRA**) 2023.

  - Deep Kernel and Image Quality Estimators for Optimizing Robotic Ultrasound Controller using Bayesian Optimization, [Paper]. **D. Raina**, SH Chandrashekhara, R. Voyles, J. Wachs, S.K. Saha. IEEE International Symposium on Medical Robotics (**ISMR**) 2023.

  - Expert-Agnostic Ultrasound Image Quality Assessment using Deep Variational Clustering, [Paper]. **D. Raina**, D. Ntentia, S.H. Chandrashekhara, R. Voyles, S.K. Saha. IEEE International Conference on Robotics and Automation (**ICRA**) 2023.

  - RUSOpt: Robotic UltraSound Probe Normalization with Bayesian Optimization for In-plane and Out-plane Scanning. **D. Raina**, A.R. Mathur, R. Voyles, J. Wachs, S.H. Chandrashekhara, S.K. Saha, International Conference on Automation Science and Engineering (**CASE**) 2023

  - Learning Robotic Ultrasound through Coaching. M.V. Balakuntala, **D. Raina**, R. Voyles, J. Wachs. Hamlyn Symposium on Medical Robotics (**HSMR**) 2023.

  - UltraGelBot: Autonomous Gel Dispenser for Robotic Ultrasound. **D. Raina**, Ziming Zhao, R. Voyles, J. Wachs, S.K. Saha, S.H. Chandrashekhara, Hamlyn Symposium on Medical Robotics (**HSMR**) 2024.

  - Slim U-Net: Efficient Anatomical Feature Preserving U-net Architecture for Ultrasound Image Segmentation, [Paper]. **D. Raina**, K. Verma, S.H. Chandrashekhara, S.K. Saha. ACM International Conference on Biomedical and Bioinformatics Engineering (**ICBBE**) 2022.

  - Comprehensive Telerobotic Ultrasound System for Abdominal Imaging: Development and in-vivo Feasibility Study, [Paper]. **D. Raina**, H. Singh, S.K. Saha, C. Arora, A. Agarwal, S.H. Chandrashekhara, K. Rangarajan, S. Nandi. IEEE International Symposium on Medical Robotics (**ISMR**) 2021.

  - A Novel Image-based Path Planning Algorithm for Eye-in-Hand Visual Servoing of a Redundant Manipulator in a Human Centered Environment, [Paper]. **D. Raina**, P. Mithun, S.V. Shah, S. Kumar. IEEE International Conference on Robot and Human Interactive Communication (**RO-MAN**), 2019.

  - Impact Modeling and Estimation for Multi-Arm Space Robot while Capturing Tumbling Orbiting Objects, [Paper]. **D. Raina**, S.V. Shah. ACM Proceedings of Advances in Robotics (**AIR**), 2017.

- **Journals**

  - USQNet: Deep Learning Model for Enhancing Quality Assessment of Ultrasound Images using Multi-scale and Fine-grained processing, [Paper]. D. Raina, S.H. Chandrashekhara, R. Voyles, J. Wachs, S.K. Saha. **IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control** 2023.

  - Tele-robotic ultrasound: an initial feasibility study, [Paper], S.H. Chandrashekhara, K. Rangarajan, A. Agrawal, S. Thulkar, S. Gamanagatti. **D. Raina**, S.K. Saha and C. Arora. World Journal of Methodology 2022.

  - Comprehensive Impact Modeling and Reactionless Control for post-capturing and manoeuvring of orbiting objects using a Multi-arm space robot, [Paper]. **D. Raina**, S. Gora, D. Maheshwari, S. V. Shah. **Acta Astronautica** 2021.

- **Workshops**

  - Local and global feature fusion for ultrasound image quality assessment: Towards autonomous ultrasound. **D. Raina**, M.V. Balakuntala, R. Voyles, S.K. Saha. Workshop on Human-centered Autonomy in Medical Robotics, IEEE International Conference on Robotics and Automation (**ICRA**) 2022 [Link]

  - Telerobotic Ultrasound: Towards safer, precise and remote diagnosis of COVID-19 patients. **D. Raina**, S. Nandi, S.K. Saha, C. Arora, K. Rangarajan and S.H. Chandrashekhara. Workshop on Autonomous System in Medicine, IEEE International Conference on Intelligent Robots and Systems (**IROS**) 2020 [Link]

  - Chitrakar: Robotic System for Drawing Jordan Curve of Facial Portrait, [Paper], A. Singhal, A. Kumar, S. Thukral, **D. Raina**, S. Kumar. Workshop on Creativity and Robotics, International Conference on Social Robotics (**ICSR**), 2020 [Link]

- **Book Chapters**

  - Modeling and Estimation of Closed-Loop Impact for Multi-arm Space Robot While Capturing a Tumbling Orbiting Object, [Paper]. **D. Raina**, S. Gora, S.V. Shah. Machines, Mechanism and Robotics, Lecture Notes in Mechanical Engineering, Springer, 2019

- **Patents**

  - Modular Robotic Ultrasound Probe Gripper with Autonomous Gel Dispenser. **D. Raina**, Z. Zhao, R. Voyles, J. Wachs, S.K. Saha, S.H. Chadrashekhara. US App. No. 63/620,115; Submitted on Jan. 11, 2024

  - Autonomous multi-bin parcel loading system. A. Singhal, H. Kahdilkar, V. Raju, **D. Raina**, V.S. Prasad, S. Thukral, R. Sinha. US2021/0253376A1; Published on Aug. 19, 2019

- **Media Coverage**

  - IIT Delhi, AIIMS New Delhi and Addverb Co-develop Telerobotic Ultrasound System During COVID Times: NDTV, Hindu, Dainik Jagran, News18, IIT Delhi, Times of India

  - Chitrakar: A system that can transform images of human faces into drawings: TechXplore, AtomsTalk