Deepak Raina

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Current Position

- **Indian Institute of Technology** — Delhi, India
  Prime Minister's Research Fellow (PMRF); Ph.D. in Robotics; GPA: 9/10 — *July 2019 – Present*

Education

- **Indian Institute of Technology** — Jodhpur, India
  Master of Technology in Mechanical Engineering; GPA: 9.24/10 — *July 2015 – June 2017*
- **Maharishi Markandeshwar Engg. College** — Ambala, India
  Bachelor of Technology in Mechanical Engineering; GPA:9/10 — *June 2011 – May 2015*

Research Interests

Medical Robotics, Telerobotics, Robot Learning from Demonstration, Vision-guided robotics, Motion-planning, Space Robotics, Vehicle Design and Dynamics

Industrial Experience

- **TCS Robotics Research and Innovation Lab** — Delhi, India
  Researcher - Robotics group — *Dec. 2017 - July 2019*
  - **Long Distance Carrier (LDC) Packing**:
    - 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 library.
    - Successfully achieved target output of 12 seconds per pick and place of the box.
  - **Vision-based Control of Redundant Robotic Manipulators**:
    - Path planning is done in image space using RRT-planner.
    - The task function approach is used where redundant DOFs are used for completion of additional tasks
    - Avoid obstacles in the environment and prevent camera view limits, robot's joint limits and singularities.
  - **Calibration: Robot and Camera**:
    - Developed a package for autonomous calibration of stereo camera with Universal Robots
    - Automated transformation detection that helps with both *eye-to-hand* and *eye-in-hand* setup of the robot.
    - Added testing support for verifying the transformation matrix.
    - Dropped calibration time from 20 minutes to 9 minutes, and resource requirement from 2 person to a 1 person.
  - **Chitrakar: Robot Artist**:
    - Developed a robotic arm to draw a human face as a recognizable non-self-intersecting loop (Jordan curve).
    - Designed motion planning module and novel gripper to complete the drawing within 30 minutes.
    - This work demonstrates the use of robotics to augment humans in executing difficult craft-work.
- **Tata Automation Limited** — Pune, India
  Trainee — *Jun. 2016 - Jul. 2016*
  - **BRABO**: This is first made-in-India industrial articulated robot. Designed and performed experiments for design evaluation, validation and testing of this robot.
  - **PID Tunning**: Reduced the vibration of robot joints by tuning the PID values for motor-controller setup.

Academic Experience

- **Doctoral Research Fellow** July 2020 - Present
  Indian Institute of Technology, Delhi
  - **Telerobotic Ultrasound (TR-US) for safety of doctors during COVID-19**:
    - Developed the control architecture to teleoperate the ultrasound probe attached to the robotic arm
    - Human trials of TR-US for abdominal imaging at All India Institute of Medical Sciences (AIIMS), Delhi

- **Masters Research Fellow** June 2016 - May 2017
  Indian Institute of Technology, Jodhpur
  - **Impact modeling and control of multi-arm space robot for capturing orbiting objects**:
    - Proposed unified framework for impact modeling and post-impact control of orbiting objects.
    - Post-impact reactionless control for stabilization of the multi-arm robot is proposed.
    - Numerical studies of impact for multi-arm open and closed-loop impacts are presented.
    - An adaptive reactionless control algorithm is proposed to capture unknown targets.
    - Effect of relative velocity and angle of approach on impact forces is analyzed.

- **Graduate Teaching Assistant**
  Indian Institute of Technology, Jodhpur and Delhi
  - MCP100: Engineering Visualization and Communication Jan-May 2020, 2021
  - MCL211: Design of Machines Aug-Dec 2019
  - ME311: Dynamics of Machines and Mechanisms Jan-May 2017, Aug-Dec 2016
  - ME222: Kinematics of Machines and Mechanisms Jan-May 2016
    - Designed and graded questions for homework assignments and quizzes
    - Conducted weekly office hours and attended classes to assist students during in-class doubts.

- **Mentor**
  Indian Institute of Technology, Jodhpur and Delhi
  - Varad Vaidya: B.Tech at Visvesvaraya National Institute of Technology (VNIT), Nagpur Jan 2021 - Present
  - Ashin Anandakrishnan: B.Tech at PSG College of Technology, Coimbatore Jan-May 2021
  - Sunil Gora: M.Tech at IIT Jodhpur Jan-May 2017
    - Mentoring interns and junior students in our group to conduct the projects assigned
    - Conducted weekly meeting to know progress and guiding them to relevant hardware, software and papers

- **Student Volunteer**
  I-Hub Foundation for Cobotics (IHFC) at IIT Delhi *Dec 2019 - Present*
  - Develop products/solutions in the area of collaborative robotics
  - Lead editor of half yearly newsletters.
  - Promoting IHFC activities in social media, writing proposals for new initiatives

- **Vice President**
  SAE INDIA Collegiate Club at MMEC Mullana *Mar 2014 - 2015*
  - Organized and oversaw activities bringing together automobile enthusiasts, popularizing automobile engineering.
  - Initiated participation of college in various automotive competitions organized by SAE, ASME etc.

- **Team Captain**
  ASME-Human Powered Vehicle Challenge (HPVC) Team *Sep 2014 - Feb 2015*
  - Led a team of 15 students having 5 departmental heads for designing and fabricating a racing tricycle.
  - Managed budget of 0.1 Million Rupees allocating it to material procurement, transport and others.

Relevant Course-Work

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

Achievements

- **Director's Honorarium (2021)**: Honored 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 2^{nd} prize in design of human-powered vehicle competition organized by ASME at IIT Delhi.
- **Indira Gandhi Merit Scholarship (2011-2015)**: Secured 7^{th} rank in 12^{th} state board exams. This Scholarship is awarded by Director of Higher Education to top 10 students.
- **Letter of Appreciation (2011)**: Awarded by Union Minister of India Mr. Anurag Thakur for excellent performance in 12^{th} state board exams

Publications

- **Journal**
  - **Chitrakar: Robotic System for Drawing Jordan Curve of Facial Portrait**, [Under review]
    Aniruddha Singhal, Ayush Kumar, Shivam Thukral, Deepak Raina, Swagat Kumar,
    Journal of Intelligent and Robotic Systems.
  - **Comprehensive Impact Modeling and Reactionless Control for post-capturing and manoeuvring of orbiting objects using a Multi-arm space robot**, [PDF]
    Deepak Raina, Sunil Gora, Dheeraj Maheshwari, Suril V. Shah,
    Acta Astronautica 2021.
  - **Design and Development for Roll Cage of All-Terrain Vehicle**, [PDF]
    Deepak Raina, Rahul Dev Gupta, Rakesh Kumar Phanden
    International Journal for Technological Research in Engineering (IJTRE), 2015.
- **Conference**
  - **Comprehensive Telerobotic Ultrasound System for Abdominal Imaging: Development and in-vivo Feasibility Study**, [Accepted]
    Deepak Raina, Hardeep Singh, Subir Kumar Saha, Chetan Arora, Ayushi Agarwal, Chandrashekhara Sh, Krithika Rangarajan, Suvayan Nandi
    International Symposium on Medical Robotics (ISMR) 2021.
  - **AI-based Modeling and Control of Robotic Systems: A Brief Tutorial**, [Accepted]
    Deepak Raina, S.K. Saha
    International Conference on Robotics and Computer Vision (ICRCV) 2021.
  - **A Novel Image-based Path Planning Algorithm for Eye-in-Hand Visual Servoing of a Redundant Manipulator in a Human Centered Environment**, [PDF]
    Deepak Raina, P. Mithun, Suril V. Shah, Swagat Kumar
    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**, [PDF]
    Deepak Raina, Suril V. Shah
    Proceedings of Advances in Robotics (AIR), 2017.
- **Workshop**
  - **Telerobotic Ultrasound: Towards safer, precise and remote diagnosis of COVID-19 patients**,
    Deepak Raina, Suvayan Nandi, Subir Kumar Saha, Chetan Arora, Krithika Rangarajan and Chandrashekhara Sh,
    Workshop on Autonomous System in Medicine,
    International Conference on Intelligent Robots and Systems (IROS) 2020 [Link]
  - **Chitrakar: Robotic System for Drawing Jordan Curve of Facial Portrait**, [PDF]
    Aniruddha Singhal, Ayush Kumar, Shivam Thukral, Deepak Raina, Swagat Kumar,
    Workshop on Creativity and Robotics,
    International Conference on Social Robotics (ICSR), 2020 [Link]
  - **Reactionless control and target manoeuvring of orbiting object in post-capture phase using a multi-arm space robot**,
    Deepak Raina, Sunil Gora, Suril V. Shah
    Workshop on Space Robotics,
    International Conference on Robotics and Automation (ICRA) 2020 [Link]

- **Book Chapters**
  - **Modeling and Estimation of Closed-Loop Impact for Multi-arm Space Robot While Capturing a Tumbling Orbiting Object**, [PDF]
    Deepak Raina, Sunil Gora, Suril V. Shah
    Machines, Mechanism and Robotics, Lecture Notes in Mechanical Engineering, Springer, 2019
- **Patents**
  - **Autonomous multi-bin parcel loading system**,
    Aniruddha Singhal, Harshad Kahdilkar, Venkat Raju, Deepak Raina, Venkatesh S. Prasad, Sivam Thukral, Rajesh Sinha,
    Filed on July 14, 2019
- **Theses**
  - **Impact Modeling and Estimation for Multi-Arm Space Robot while Capturing Tumbling Orbiting Objects**,
    Supervisor: Prof. Suril V. Shah,
    Department of Mechanical Engineering, IIT Jodhpur
- **News**
  - **IIT Delhi, AIIMS New Delhi and Addverb Co-develop Telerobotic Ultrasound System During COVID Times**
    NDTV: https://www.ndtv.com/education/iit-delhi-aiims-develop-telerobotic-ultrasound-system
    Hindu: https://www.thehindu.com/news/cities/Delhi/iit-aiims-develop-telerobotic-ultrasound-system
    Dainik Jagran: https://www.jagran.com/delhi/iit-delhi-scientists-did-wonders-in-the-field-of-ultrasound
    News18: https://www.news18.com/news/education-career/iit-delhi-aiims-researchers-jointly-create-remote-ultrasound-system
    IITD: https://home.iitd.ac.in/show.php?id=37&in_sections=Press
    Times of India: https://timesofindia.indiatimes.com/city/delhi/new-robotic-tech-for-ultrasound
  - **Chitrakar: A system that can transform images of human faces into drawings**
    TechXplore: https://techxplore.com/news/2021-01-chitrakar-images-human.html
    AtomsTalk: https://atomstalk.com/news/chitrakar-a-robotic-artist.html

Skills

- **Programming Languages**: Python, C++, HTML
- **Tools**: ROS, Gazebo, MoveIt!, pyTorch, Pybullet, OpenCV, ADAMS; MATLAB, Qt-creator; Solidworks, ANSYS
- **Hardware**: Universal robots (UR10, UR5), RG2 gripper, Intel RealSense SR300 camera, Geomagic Touch haptic device

Academic Projects

- **Course Projects**
  Masters and Doctorate
  - Symbolic motion planning of mobile manipulator in a room environment
  - Bayesian state estimation of underwater robot using acoustic observations
  - Hand gesture-based control of Music Player using Convolutional Neural Network (CNN)
  - Potential field-based motion planning of a serial robot among obstacles
  - Image-based visual servoing (IBVS) controller for the UR5 robotic arm
  - Solidworks API for triangulation of solid model using Delaunay Triangulation
  - Adaptive slicing procedure for layered manufacturing and generate G-Codes
  - Acceleration, braking, ride and steering dynamics calculation of Mahindra XUV500 and simulation in AdamsCar
- **Design and fabrication of Off-Road Vehicle** SAE BAJA 2015
  Lead Designer, Vice-captain *March 2014 - 15*
  - Designed a roll-cage for this vehicle using design optimization techniques
  - The roll-cage, suspension arms, hub and knuckle was tested against all modes of failure with ANSYS
  - Worked on braking system design and dynamics
  - Prepared DFMEA for the vehicle. **Ranked** 36^{th} **out of** 120 **teams**
- **Design and fabrication of Human-Powered Vehicle** ASME HPVC 2014
  Captain, Lead Designer *Sep 2013-Feb 2014*
  - Designed a lightweight and stable HPV using tadpole configuration with Rollover Protection System
  - Performed ergonomics study so that human can apply its peak power with less fatigue
  - The fairing is designed and validated to reduce drag forces. **Won** 2^{nd} **prize in Design**

Extra Co-curricular activities

- Represented M.M. University as a player in All India Inter University Badminton Championship
- Volunteering under National Service Scheme (NSS) for 2 years including 7 days' special camp every 6 months
- Green Belt in Martial Arts