PORTFOLIO

Pulkit Goyal
pulkitgoyal.work@gmail.com
+49 174 650 4022

Areas of Interest

Robotics, Machine Learning, *Deep Learning, Reinforcement Learning, Control Theory, Mathematics*
Cybernetics, *Theoretical/Computational Neuroscience, Dynamical Systems, Brain-Computer Interfaces*

Education

- **University of Tübingen** — Tübingen, Germany
  Master of Science (M.Sc.); GPA: 1.30 (∼90% / "very good") — *Oct 2021 – May 2024*
  Course: Neural Information Processing
  Thesis — Building Visual Semantic Bias in Curious Exploration during Free Play
  Relevant Coursework:
  • Machine Learning (Statistical/Probabilistic) • Deep Learning • Computer Vision • Reinforcement Learning
  • RL for Language Model Training • Automated Machine Learning • Signal Processing • Advanced Statistics
  • Neural Data Science • Neural Dynamics/Coding • Complex Networks • Computational Cognitive Science
  • Computational Systems Neuroscience • Computational Motor Control • Computational Models of Vision
  • Learning and Memory • Neurophysiology • Neurotechnology • Human-Robot Interaction
- **Indian Institute of Technology (IIT) Roorkee** — Roorkee, India
  Bachelor of Technology (B.Tech.); GPA: 85.68% — *Jul 2014 – May 2018*
  Major: Mechanical Engineering | Minor: Computer Science
  Thesis — Mathematical Modeling of Humanoid Robot Gait on a Vibrating Beam
  Relevant Coursework:
  • Advanced Robotics • Automatic Control • Artificial Neural Networks • Mathematical Imaging Techniques
  • Programming and Data Structures • Operating Systems • Computer Graphics • Discreet Structures
  • Design and Analysis of Algorithms • Mathematical Statistics • Numerical Methods • Mechatronics
  • Vibration and Noise • Kinematics and Dynamics of Machines • Tensors and Differential Geometry
- **Delhi Public School Indore** — Indore, India
  Mathematics and Science; GPA: 89.4% — *Jul 2012 – Mar 2014*

Academic Achievements (Awards/Honors/Scholarships)

- **Trust Scholarship — Dean of Resources and Alumni Affairs, IIT Roorkee** — *2019*
  For overall performance during B.Tech.
- **Annual Excellence Award — IIT Roorkee Heritage Foundation** — *2018*
  For outstanding curricular, co-curricular, and extra-curricular achievements
- **Summer Undergraduate Research Award — SRIC Office, IIT Roorkee** — *2016*
  For the project — Design of 8-DOF Redundant Manipulator Robot on Holonomic Platform
- **Certificate of Merit in Mathematics (Top 0.1%; Marks: 100/100)** — *2014*
  From AISSCE, Central Board of Secondary Education, India
- **JEE Advanced — National Rank: 1331** — *2014*
  In 150,000 shortlisted candidates from 1.5 million students

Work Experience (in Industry)

- **Software and Embedded Systems Engineer** — Tokyo, Japan
  Global IoT & Innovation Headquarters, JIG-SAW INC. | [recommendation_letter] — *Oct 2018 – Sep 2021*
  - Developed edge-processing solutions for IoT applications using machine learning and computer vision (digitizing analog gauges using cameras, OCR for live license plate recognition, parking lot occupancy...)
  - Served as the lead technical advisor for IoT business expansion in North America
  - Lead a team to design/conduct extensive lab experiments and develop libraries for industrial sensors
  - Developed Linux tools/firmware/libraries for proprietary IoT gateway device
  - Developed automation tools for testing, instrumentation, deployment (CI/CD), and documentation
  - Prepared technical demonstrations for novel IoT use cases and showcased them in expos like MWC (Barcelona), IoT World (San Jose), IoT M2M (Tokyo), and AWS Summit (Tokyo)
  - Designed IoT AR application on Microsoft HoloLens and Sony SmartGlass for industrial monitoring
  - Architected product backend on both AWS and GCP
  - Developed testing suite for backend Django-REST Framework API

- **Signal Processing and Machine Learning Engineer** — Tokyo, Japan
  Resonest Corporation | *Part-Time* — *Nov 2020 – Mar 2021*
  - Formulated data processing pipeline and deep learning (ANFIS) model to infer soil density during operation of compaction machinery on the construction field using telemetry data from multiple sensors

- **Industrial Automation Engineer** — Guntur, India
  Spices Division, ITC Ltd. | *Intern* | [recommendation_letter] — *May 2017 – July 2017*
  Project — Mechanization of De-stemming Operation of Dried Chili
  - Innovated mechatronic solutions for the automation of the manual de-stemming operation on chili
  - Identified technologies, designed mechanisms, and oversaw fabrication of novel chili de-stemming machines
  - Proposed solutions with 7-fold decrease in the manufacturing cost, increasing profits by ~$500k/year

- **Robotics and Control Engineer** — Roorkee, India
  Team Robocon IIT Roorkee | *Competitive Robotics* | *ABU Robocon – Asia-Pacific Competition* — *Jan 2015 – Apr 2018*
  - Designed and built robots in year-long projects to compete in ABU Robocon 2016, 2017, and 2018
  - Developed control systems for navigation of several semi-automatic and automatic wheeled-robots using sensor fusion, signal processing, image processing/computer vision, and machine learning
  - Worked on sensor testing/integration + mechanical design and fabrication of the robots
  - 2016: *5^{th}/108 Teams + Best Aesthetics Award* | 2018: *7^{th}/107 Teams + Best Innovative Award*

Research Experience

- **Research Intern (Cognitive Neurorobotics)** — Okinawa, Japan
  Cognitive Neurorobotics Research Unit, Okinawa Institute of Science and Technology (OIST) — *May 2024 – Jan 2025*
  - Modeled obsessive-compulsive disorder in self-exploring model-based RL, based on the Bayesian free-energy principle and active inference framework [interim_report] [proposal_presentation]
  - Studied dysfunctional balance of habitual and goal-directed behavior

- **Research Intern (Brain Computer Interfaces)** — Vitznau, Switzerland
  cereneo Foundation (cefir); in collab. with RELab, ETH Zürich | [recommendation_letter] — *Dec 2022 – Mar 2023*
  - Authored Python library to easily build complete fNIRS data pre-processing pipelines [code] [poster] [report]
  - Investigated markers of attentional load in the intraparietal sulcus (IPS) using fNIRS [presentation]

- **Computational Research Assistant (Neuroscience)** — Tübingen, Germany
  Natural Intelligence Lab, Max Plank Institute for Biological Cybernetics — *Sep 2022 – Nov 2022*
  - Reviewed various dynamical recurrent network models of the primary visual cortex (V1) [presentation]
  - Analysed fMRI (retinotopy) data from the Human Connectome Project (S1200) [code]

- **Computational Research Assistant (Machine Learning / Neuroscience)** — Tübingen, Germany
  Burgalossi Lab, Center for Integrative Neuroscience (CIN) | *Part-Time (HiWi)* — *Nov 2021 – Aug 2022*
  - Designed classifier for electrophysiological and morphological neuronal recordings from the Locus Coereleus
  - Created processing and visualization pipelines for social experiments in mice, in Bonsai and MATLAB
  - Developed Dockerized Python application to generate and synchronize animated spike plots [code]

Other Research Projects

- **Building Visual Semantic Bias in Curious Exploration during Free Play** — University of Tübingen
  Master's Thesis — Autonomous Learning Group, Max Plank Institute of Intelligent Systems — *Sep 2023 – Apr 2024*
  - Developed a model-based planner for semantic expression during free play in AI, akin to free play observed in humans, using large vision-language models (CLIP), in custom creative environments like Tangram
  - Investigated whether bias towards symmetry and compression help in creative semantic expression [thesis]

- **Mathematical Modeling of Humanoid Robot Gait on a Vibrating Beam** — IIT Roorkee
  B.Tech. Project — 2nd best project in 32 projects in the department | [recommendation_letter] — *Aug 2017 – May 2018*
  - Studied human gait and analyzed vibrations generated due to human-beam interaction in the sagittal plane
  - Modeled dynamics of biped robot using Lagrangian mechanics and bond graphs
  - Conceptualised a feed-forward control system to stabilize gait on the basis of vibrations induced due to walking and verified it on a simplistic biped robot [report]

- **Design of 8-DOF Redundant Manipulator Robot on Holonomic Platform** — IIT Roorkee
  Robotics and Control Lab, IIT Roorkee | *SURA 2016* | [recommendation_letter] — *May 2016 – Dec 2016*
  - Engaged in design, structural analysis, and metal fabrication of the manipulator and 3-omni-wheel chassis
  - Automated the robot using encoders, hall effect sensors, and optical flow sensors (in *IEC-61131-3*)
  - Modeled forward/inverse kinematics/dynamics of the robot using bond graphs
  - Developed path planning algorithms for trajectory generation/optimization in MATLAB [report]

Academic Projects

- **An Evolutionary Approach to a Modified Multi-Objective Job-Shop Problem** — IIT Roorkee
  Course Project, Operating Systems — *Mar 2018*
  - Researched about scheduling problems and the existing approaches to their solution
  - Compared evolutionary algorithms (GA, PSO, SA, and ACO) to optimize the number of machines given a time constraint, single task jobs and identical machines in MATLAB [presentation] [report]

- **Digital Circlism (Algorithmic Art)** — IIT Roorkee
  Course Project, Computer Graphics — *Oct 2017*
  - Implemented mean-shift segmentation and euclidean distance transform for finding the best fit for different size circles in a coloured image (digital circlism) [report]

- **Comparison of Regression Techniques for Short-Term Time-Series Prediction** — IIT Roorkee
  Course Project, Artificial Neural Networks — *Apr 2017*
  - Conducted a comparative study of LSTM, SVR, and ARIMA for short-term time-series prediction
  - Used Sklearn library for SVR and TensorFlow for LSTM [report]

- **Thermal and Structural Analysis of Simple Households** — IIT Roorkee
  Lab Based Project — *Feb 2017*
  - Simulated and compared various typical house structures made of different natural materials
  - Ranked these materials on their ability to withstand earthquakes in different temperature conditions
  - Mapped the best natural material to build houses in different regions of India [report]

- **Stereo-Imaging Using Segmentation** — IIT Roorkee
  Course Project, Mathematical Imaging Techniques — *Oct 2016*
  - Reviewed existing stereo imaging techniques and formulated a method to generate the disparity map using hierarchical segmentation and iterative cluster comparison for stereo-imaging [presentation] [report]

- **Intelligent Traffic Control Model Using IoT** — IIT Roorkee
  Course Project, Fundamentals of Innovation and Business Models — *Sep 2016*
  - Conceptualized an IoT model to mitigate the problem of traffic by exploiting the four second rule [presentation] [report]

- **Design of Windmill** — IIT Roorkee
  Course Project, Engineering Analysis And Design — *Oct 2015*
  - Designed and compared different base designs for optimum strength and stability of windmill [report]

Independent Projects

- **Servo Controlled, 3D-Line Following Robot Using Computer Vision** — IIT Roorkee
  Team Robocon IIT Roorkee — *Feb 2016*
  - Developed a 3-wheeled robot with front wheel steering for line following over a contoured surface, streaming image from an on-board camera, finding the orientation of line using edge/contour detection algorithms, and passing appropriate signal to a servo motor for steering
  - Experimented with multiprocessing and GPU rendering for increasing speed

- **General Curve Tracing – Four (Omni-)Wheel Holonomic Robot** — IIT Roorkee
  Team Robocon IIT Roorkee — *Oct 2015*
  - Designed a control system for a holonomic four-wheeled robot to trace any explicit mathematical curve
  - Improved magnetometer accuracy using regression to calibrate and obtain the sensor mapping [report]

- **Coordinate Based Navigation – Four (Mecanum-)Wheel Holonomic Robot** — IIT Roorkee
  Team Robocon IIT Roorkee — *Sep 2015*
  - Built a point-to-point navigation system for a holonomic robot with or without orientation lock
  - Interfaced magnetometer, IR sensor, and encoder; Kalman filter for smoothing sensor data

- **Stair Climbing Robot** — IIT Roorkee
  Team Robocon IIT Roorkee — *Aug 2015*
  - Designed a small pneumatic based RC wheeled robot that could climb stairs of variable dimensions

- **Fuzzy Logic Library** — IIT Roorkee
  Team Robocon IIT Roorkee — *July 2015*
  - Formulated a generalized scalable fuzzification rule base (on different membership functions/methods)
  - Developed a fuzzy logic library in C++ for control of wheeled robots [github-directory]

- **Quadcopter** — IIT Roorkee
  Best Project, Models and Robotics Section; Srishti 2015 — *Mar 2015*
  - Fabricated and automated a quad-copter using BLDC motors, Arduino, and IMU
  - Implemented and compared various control algorithms for stable flight

Additional Experience (Conferences/Workshops/Summer-Schools/Competitions)

- **NeNa 2023** — Frankfurt, Germany
  Project — fnirsPy: *A Sufficient, Easy, and Flexible fNIRS Preprocessing Library* — *Sep 2023*
  [poster] [picture] [presentation] [report] [code]

- **SRISTI-UNICEF Summer School on Inclusive Innovations in Rural India** — Gandhinagar, India
  Project — *An Ergonomic Chula (Stove): 40% More Efficient than Traditional Wood-Based Stove* — *Jun 2018*
  - Analysed the design of "chula" (traditional wood-based-stove used in rural India)
  - Proposed improvements that can be easily adapted by existing users with a few modifications, and could be fabricated using biodegradable materials freely and readily available in the area [presentation] [report]

- **6th Inter-IIT Tech Meet** — IIT Madras
  2nd Position in Engineers' Conclave — *Jan 2018*
  - Automated an equatorial mount telescope using stepper motors, Raspberry Pi, and 3-D printed parts
  - Developed a Python API to interface with Stellarium to automatically point the telescope [report]

- **5th Inter-IIT Tech Meet** — IIT Kanpur
  Represented IIT Roorkee in Indoor Localization Competition — *March 2017*
  - Designed a wheeled robot to locate a Wi-Fi beacon based on the received signal strength [picture]

- **Industrial Automation Workshop** — Gurgaon, India
  Delta Electronics — *Feb 2017*
  - Got training with hands-on experience on programming industrial standard PLC, motors, and electric drives
  - Competed in "Warehouse Automation and Monitoring" IIoT competition at national level [proposal]

- **Techfest 2016–17** — IIT Bombay
  Ranked in the Top 5 Teams in Resemblance – A Satellite Image Classification Competition — *Dec 2016*
  - Implemented a SVM based classifier to classify satellite images in C++, using LIBSVM [report]

- **Short Term Course** — IIT Roorkee
  Modelling and Control of Robots — *July 2016*

- **Code.Fun.Do** — IIT Roorkee
  Hackathon, Microsoft — *Oct 2015, Mar 2016 and Mar 2018*
  - 2015 — C# and XML app to detect material of an object using the sound generated on its vibration
  - 2016 — Android app implementing a CNN classifier for crop disease detection using leaf images
  - 2018 — A web app that shares the victim's ID and medical data to nearest hospital in case of emergency

- **Robosapiens** — IIT Roorkee
  Cognizance 2015 (Annual Technology Festival, IIT Roorkee) — *Mar 2015*
  - Won 2nd position in over 50 teams from colleges all across the country
  - Fabricated two small wheeled robots, automatic (line following) and manual robot with a pneumatic gripper capable of picking and throwing small sized wooden blocks at small distances (5m-6m)

Leadership/Positions of Responsibility

- **Teaching Assistant,** | **Department of Mechanical Engineering, IIT Roorkee**
  Engineering Drawing — *Jan 2018 – Apr 2018*
  Programming And Data Structures — *Oct 2017 – Nov 2017*
  - Tutored a batch of 100 students by conducting supplementary lectures and discussions after class hours

- **Convener**
  Srishti 2018 (Annual Techno-Hobby Exhibition, IIT Roorkee) — *Jan 2018 – Mar 2018*
  - Srishti is the three-day annual techno hobby exhibition of IIT-R in which all the major technical groups of the campus exhibit their past year's work
  - Oversaw the team that planned, organized, and managed the event with more than 500 exhibitors and 73 projects in robotics, AI, formula-style race cars, astronomy, etc.

- **Secretary**
  Tinkering Lab, IIT Roorkee — *Aug 2017 – Apr 2018*
  - Tinkering Lab is the state-of-the-art rapid prototyping lab of IIT-R that was established to encourage the spirit of innovation, invention, and entrepreneurship among students
  - As the first student secretary of the lab, I took responsibility to promote its usage among students and professors for research/independent projects, and making the access to the lab easy for all by digitally reforming the lab procedures

- **Executive Member**
  Students' Technical Council, IIT Roorkee — *Jan 2017 – Apr 2018*
  - STC is the technical decision-making body of IIT-R, composed of students, professors, and deans which oversees the workings of all technical groups, organizes competitions, promotes technical activities and projects, and effectuates technical changes in the campus
  - One of the 16 nominated student members

- **Senior Student Mentor**
  Student Mentorship Program, IIT Roorkee — *Sep 2016 – Apr 2018*
  - I was one of the few students selected to mentor freshmen to make their transition into campus life easier by counselling them on topics of academic and non-academic nature

- **Joint Secretary**
  Models and Robotics Section (MaRS), IIT Roorkee — *Apr 2016 – Apr 2017*
  - MaRS is the official robotics club of IIT-R which mentors students in robotics with hands-on projects
  - Took open lectures on robotics and guided more than 100 students from all academic years and programs, for projects like Waste Segregation Robot, Robotic Band, Life-Sized Humanoid, etc., which were exhibited in the college's annual exhibition [github]

- **Robotics Event Organizer**
  Cognizance 2016 (Annual Technology Festival, IIT Roorkee) — *Jan 2016 – Mar 2016*
  - Organized a center-stage automatic ground robot obstacle maze course competition – "Cyborg Break-In"
  - Participation of over 200 students from universities all over India

Skills

Programming	Python (9Y), C/C++ (4Y), JavaScript/TypeScript (3Y), Linux/Shell Script, Go, C#, LaTeX
Software	MATLAB, Mathematica, GNU Octave, ROS, NumPy, PyTorch, scikit-learn, OpenCV, Pandas, AWS, GCP, Git, Docker, SolidWorks, Fusion 360, KiCad, Eagle, ANSYS, ADAMS, AutoCAD
Hardware	Arduino, Raspberry Pi, NVIDIA Jetson Nano, AVR, STM-32
Miscellaneous	Cloud Development, Network Security, Instrumentation, CI/CD, Microcontrollers, Sensors, Hardware Communication Protocols, Electronic Design, CAD/CAM
Languages	English (native), Hindi (native), Japanese (basic ∼*JLPT-N5*), German (∼*A1*), French (beginner) *[TOEFL iBT — 112/120, GRE — 320/340 (Quantitative — 170/170, Verbal — 150/170)]*

Hobbies (Exhaustive List)

• Hiking/Trekking • Camping • Biking • Backpacking • Surfing • Football • Table Tennis • Shooting • Cooking • Pool • Card Games • Board Games • Photography (landscape, architecture, fauna) • Rock Music • Guitar • Collecting (stamps, coins, pine cones, random flora, cultural artifacts, pamphlets, software) • Puzzles • Haiku • Letter Writing • Reading (fantasy, fiction, thriller) • Audiobooks • Manga • History • Art History • Philosophy • Astronomy • Astrophotography • Mathematics • Physics • Neuroscience • Robotics • Artificial Intelligence • Automation • Open Source • Linux • Software Customization

Extra-Curricular Achievements

- **Member, National Sports Organization (NSO)** — IIT Roorkee
  Among 200 students selected to be a member of NSO (Proficiency: Table Tennis) — *2014 – 2015*
- **2nd Position, Intra-College Table Tennis Competition, 2016 and 2018** — IIT Roorkee
- **Marathon** — IIT Roorkee
  Sangram 2017 (Annual Sports Festival, IIT Roorkee) — *2017*
- **Football** — Delhi Public School, Indore
  School Team — *2011 – 2012*
- **Table Tennis** — Ujjain, India
  Division Level, Under 17 — *2011*
- **Chess** — Mandsaur, India
  District Level, Under 17 — *2011*

Academic References

Prof. Dr. Georg Martius
Professor (Master's Thesis Supervisor)
University of Tübingen
Tübingen, Germany
✉ georg.martius@tuebingen.mpg.de

Prof. Dr. Andrea Burgalossi
Professor
University of Tübingen
Werner Reichardt Center for Integrative Neuroscience
Tübingen, Germany
✉ andrea.burgalossi@cin.uni-tuebingen.de

Prof. Pushparaj M. Pathak
Professor
Indian Institute of Technology (IIT) Roorkee
Roorkee, India
✉ pushparaj.pathak@me.iitr.ac.in
[recommendation_letter] (2021)

Prof. Sanjeev Kumar
Professor
Indian Institute of Technology (IIT) Roorkee
Roorkee, India
✉ sanjeev.kumar@ma.iitr.ac.in
[recommendation_letter] (2016)

Prof. Jun Tani
Professor
Okinawa Institute of Science and Technology (OIST)
Okinawa, Japan
✉ jun.tani@oist.jp

Dr. Josef G. Schönhammer
Researcher
University of Zürich (UZH)
cereneo Foundation (cefir)
Vitznau, Switzerland
✉ josef.schoenhammer@cereneo.foundation
[recommendation_letter] (2023)

Prof. Anil Kumar
Associate Professor (B.Tech. Project Supervisor)
Indian Institute of Technology (IIT) Roorkee
Roorkee, India
✉ anil.kumar@me.iitr.ac.in
[recommendation_letter] (2021)

Prof. Arup Kumar Das
Associate Professor
Indian Institute of Technology (IIT) Roorkee
Roorkee, India
✉ arup.das@ma.iitr.ac.in
[recommendation_letter] (2017)

Industry References

Shuichi Watanabe
Manager, Software Development
IoT Division, JIG-SAW Inc.
Tokyo, Japan
✉ shuichi.watanabe@jp.jig-saw.com
[recommendation_letter] (2021)

Simanta Ghosh
Manager, Projects
Agri Business Division, ILTD, ITC Ltd.
Guntur, India
✉ simanta.ghosh@itc.in
[recommendation_letter] (2017)

Hirotoshi Maegawa
President
Resonest Corporation
Tokyo, Japan
✉ maegawa@resonests.onmicrosoft.com