Curriculum Vitae of **Pranav C. Khandelwal**

Postdoctoral Researcher
Max Planck Institute for Intelligent Systems

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Academic positions

2021-now **Senior Postdoctoral Researcher**
Max Planck Institute for Intelligent Systems, Stuttgart, Germany (MPI-IS)
Locomotion in Biorobotic and Somatic Systems

2021-now **UNC Affiliate/Collaborator**
University of North Carolina at Chapel Hill, USA

2021 **PhD in Biology**
University of North Carolina at Chapel Hill, USA
Dissertation: How do animals glide in their natural habitat? A holistic approach using the flying lizard *Draco dussumieri*
Advisor: Dr. Tyson L. Hedrick, Comparative Biomechanics Lab

2013-14 **Junior Research Fellow**
Biomechanics Lab, Indian Institute of Science, India

2013 **Masters in Physics with a minor in Biology**
Indian Institute of Science Education and Research, Trivandrum, India (IISER)
Thesis: A characterizational study of doped PEDOT:PSS as viable tissue engineered and optoelectronic constructs
Advisor(s): Dr. Manoj A. G. Namboothiry, MOBEL, School of Physics, IISER
Dr. Namrata Gundiah, Biomechanics Lab, Indian Institute of Science

Publications

Khandelwal, P. C., & Hedrick, T. L. (2022). Combined effects of body posture and three-dimensional wing shape enable efficient gliding in flying lizards. Sci Rep 12, 1793 (2022). https://doi.org/10.1038/s41598-022-05739-1.

Chellapurath, M., **Khandelwal, P. C.**, Rottier, T., Schwab, F., & Jusufi, A. (2022). Morphologically Adaptive Crash Landing on a Wall: Soft-Bodied Models of Gliding Geckos with Varying Material Stiffnesses. Advanced Intelligent Systems, 2200120.

Khandelwal, P. C., & Hedrick, T. L. (2020). How biomechanics, path planning and sensing enable gliding flight in a natural environment. *Proceedings of the Royal Society B*, *287*(1921), 20192888.

Khandelwal, P. C., Agrawal, S. S., Namboothiry, M. A., & Gundiah, N. (2014). Fabrication of a novel biomaterial with enhanced mechanical and conducting properties. *Journal of Materials Chemistry B*, *2*(42), 7327-7333.

Book Chapter

Khandelwal, P. C., Ross, S. D., Dong, H., Socha, J. J. (2022). Convergence in Gliding Animals: Morphology, Behavior, and Mechanics. Chapter in press in Convergent Evolution – Animal Form and Function (Springer). Eds V. Bels and P. Legreneur.

Published conference abstracts

*indicates undergraduate student mentee

Khandelwal, P. C., Socha J J., Hedrick, T L., Jusufi, A (2022). The role of tail during reorientation in flying lizards. *Society for Integrative and Comparative Biology Annual Meeting*, Jan 3-7, Phoenix, AZ, USA.

Khandelwal, P. C., Hedrick T L (2020). Gliding through clutter – obstacle avoidance and path planning in the flying lizard *Draco dussumieiri*. *Society for Integrative and Comparative Biology Annual Meeting*, Jan 3-7, Austin, TX, USA.

Khandelwal, P. C., Hedrick T L (2018). Take-off biomechanics in gliding lizards. *Society for Integrative and Comparative Biology Annual Meeting*, Jan 3-7, San Francisco, CA, USA.

Khandelwal, P. C., Hedrick, T L (2017). The short and long of gliding. *Society for Integrative and Comparative Biology Annual Meeting*, Jan 4-8, New Orleans, LA, USA.

*Yu, S., **Khandelwal, P. C.**, *Gardner, H., Hedrick, T. L. (2017). Continuous aerodynamic pitch perturbation of hawkmoths. *Society for Integrative and Comparative Biology Annual Meeting*, Jan 4-8, New Orleans, LA, USA.

Khandelwal, P. C., Evangelista, D., Hedrick, T. L. (2016). The glide of the dragon – glide characterization and performance in *Draco dussumieri*. *Society for Integrative and Comparative Biology Annual Meeting*, Jan 3-7, Portland, OR, USA.

Evangelista, D., **Khandelwal, P. C.**, Rader, J., Hedrick, T. L. (2015). Free flight kinematics of massed Chimney Swifts entering a chimney roost at dusk. *Society for Integrative and Comparative Biology Annual Meeting*, Jan 3-7, West Palm Beach, FL, USA.

Journals served as manuscript reviewer

Proceedings of the Royal Society B

Journal of Experimental Biology

Open access data

Khandelwal P. C. & Hedrick T. L., (2022). Free-flight kinematics and aerodynamics data on flying lizards. https://doi.org/10.6084/m9.figshare.16602368

Khandelwal P. C. & Hedrick T. L., (2020). Kinematic data on freely behaving flying lizards. https://doi.org/10.5061/dryad.70rxwdbt6

Contributed grant writing

2022	Swiss National Science Foundation, ‘’Soft Paleo-robotics: Recreating Ancient Marine Reptiles' Agile Swimming with Soft Robo-physical Modelling’’, $1,000,000 (PI - Dr. Ardian Jusufi)
2022	Swiss National Science Foundation, “Versa–Tail: Soft biomimetic Limbs enable agile Locomotion Transitions”, $1,500,000 (PI - Dr. Ardian Jusufi)
2021	European Research Council Starting Grant, “Deciphering how animals achieve robust locomotion using soft robotics.”, $1,500,000 (PI – Dr. Ardian Jusufi)

Awards & Fellowships

2020 $5,000 - Gordan W. and Janice L. Plumbee Summer Research Fellowship

2019 $2,500 - Kenan Trust Graduate Student Research Award

2016 $250 – 2nd place in animal superpowers grant challenge

2008-13 INSPIRE fellowship, awarded by the Government of India

Teaching experience

2015-20 **Teaching Instructor** for Introductory lab BIOL 101
Independently conducted the course including lecturing, test making, grading, and experiments. The course consisted of over 60 students each semester

2020 **Undergraduate tutor**
Tutored UNC athletes in100 level Math, Physics, Biology, Computer Science

2015-20 **Undergraduate mentor**
Mentored 4 students as part of their Undergraduate research project. The projects were presented at regional and national conferences.

Invited talks

2021 Talk: How do animals glide in their natural habitat?
Centre for the Advanced Study of Collective Behavior, Konstanz, Germany

2020 Talk: Markerless tracking of animal movement using deep learning
Undergraduate course on deep learning in Biology, UNC Chapel Hill, USA

2016 Talk: Gliding locomotion in animals
Morehead planetarium family science day event on flight, Chapel Hill, USA

Software for teaching and research

2020 **Virtual teaching lab for Biology 101**
Developed 5 interactive apps simulating lab experiments used by ~500 undergraduate students
The apps have allowed instructors to successfully conduct remote labs and students to actively engage and learn experimental design, conduct experiments, and collect data for analysis

2020 **Handling images for a Deep Learning toolbox**
An app to quickly transition back and forth between pre-existing annotating video package DLTdv and deep learning toolbox DeepLabCut. The app functionality can read video, extract annotated frames, and create datasets for neural network training and refinement

2018 **Saving bats! Processing 3D trajectories and kinematics**
A user-friendly app to visualize field recordings of bat flight in the presence of wind turbines. App processes 3D position data and generates kinematic metrics like velocity, acceleration, and track curvature to inform decisions for wind energy facilities to minimize the detrimental effect of wind turbine on bats

2017 **Let's measure! Extracting morphometric measurements**
A graphical interface to read images, calibrate them and measure user-defined features
Stores a detailed log of time, pixel location, version, and measurements of user, allowing to check and average out measurement errors across multiple users for the same feature measurement

2016 **Assessing student academic performance**
Automated student performance monitoring for a class of ~400 students for the Introductory Biology 101 course
The program routinely gathered assignment/test scores from database and performed analysis to list students with potential grade concerns

Workshops attended

2022 Movement academy, Technische Universität Darmstadt, Germany
Movement control in humans and animals bringing together researchers from academia, industry, and medical practitioners

2020 DeepLabCut workshop, Rowland Institute, Cambridge, USA
Deep learning for markerless animal tracking

Professional affiliations

2015-21 Society for Integrative and Comparative Biology

Professional service

2021-23 PostdocNet election committee member at MPI-IS

2022 Division of Animal Behavior poster judge at the SICB national meeting

2021 Grassroots grant reviewer. Internal grants at MPI-IS

2021 IMPRS PhD program application evaluator for MPI-IS

2018 Session co-chair, Flight: Birds, Bats and Gliders, SICB national meeting

2018 Graduate student ambassador, Biology Department, UNC Chapel Hill

2017-19 Treasurer and Event Organizer, Badminton Club, UNC Chapel Hill

2016-17 Officer and Webmaster, Biology Graduate Student Association, UNC Chapel Hill

Science outreach and community service

2022 Guest Scientist for discussion on gliding biomechanics of flying lizards
Undergraduate course on animal biomechanics
Saint Mary's College, Notre Dame, Indiana, USA

2021 How Did Animals Inspire Human Flight? - STEM in 30: Season 8, Episode 4
Smithsonian National Air and Space museum, USA
Contributed field season footage of the lizard *Draco dussumieiri* to showcase gliding flight in flying lizards

2020	Science feature for Indian news outlet NDTV Gadgets Authored an article that candidly talks about the use and challenges of technology for field data collection. The article can be found here
2019	Wild Karnataka documentary, State of Karnataka, India Part of the research team and supported video recording of flying lizards in the jungle
2015-19	Science Expo, UNC Chapel Hill Discussing insect flight with hawkmoth flight demonstrations for the public
2018	Meet a scientist, Science Expo, UNC Chapel Hill One-on-one interactions with all age groups answering questions on animal locomotion
2017	Public outreach through regular updates during 2017 field season All updates can be accessed here
2016	Darwin Day, North Carolina Museum of Natural Sciences, NC, USA Discussing insect flight with hawkmoth flight demonstrations for the public
2014-20	SEWA International (Non-profit organization), RTP Chapter, USA In charge of organizing monthly community service activities

Press and media

2022	BNR Dutch news radio interview on flying lizard aerodynamics
2020	Outside JEB - Flying lizards plan ahead to avoid clutter
2020	Endeavors – Biomechanics on the Fly
2020	Crowdfunding campaign - How the dragon glides: the biomechanics of a flying lizard
2016	YouTube – How *Draco* glide in a cluttered environment

Research profiles

Google Scholar	https://scholar.google.com/citations?user=vFFYrvsAAAAJ&hl=en
ORCiD	https://orcid.org/0000-0002-0589-4467
ResearchGate	https://www.researchgate.net/profile/Pranav-Khandelwal

Detailed description of research experience

Senior Postdoctoral Researcher, MPI-IS, Stuttgart, Germany

Project Development and Management

- Leading two projects to investigate the role of tail during gliding in flying lizards and in gap jumping in squirrels
- One of three researchers leading development of an interdisciplinary project to improve gliding performance of drones and micro aerial vehicles inspired from flying lizards.

Bio-inspired soft robotics

- *Soft model design*: co-designed a soft physical model to test passive perching mechanism in gliding gecko
- *Soft model evaluation*: Automated data collection using high speed videography and DeepLabCut to quantify perching kinematics and success rate.

PhD Researcher, Comparative Biomechanics Lab, UNC Chapel Hill, USA

Experimental Design and Innovation

- *Wind tunnel design*: designed wind tunnel to provide pitch perturbation to hawkmoths in hovering flight and performed Particle Image Velocimetry to characterize wind flow
- *Motion Capture arena:* designed an arena measuring 5.5 x 5 m in the rainforest with 7 GoPro cameras to perform high speed 3D motion tracking of flying lizards

Computer Vision

- *Camera calibration*: generated fisheye camera calibration pipeline for consumer-grade cameras
- *Multi-camera 3D tracking:* implemented 3D tracking using up to 7 GoPro cameras simultaneously allowing 3D pose estimation of gliding lizards in flight; tracking resolution of < 1 cm
- *Deep learning for object tracking:* automated multi-object detections using Deep learning and background subtraction saving ~150 hours of manual tracking

Data and Motion analysis

- *Data smoothing and filtering:* implemented smoothing of motion capture time series data using interpolation and signal processing techniques
- *Kinematic analysis:* scripted functions to calculate velocity, acceleration, forces, and custom motion metrics for hypotheses testing and measuring locomotory performance
- *Algorithm Development:* developed algorithms to identify and characterize key behavioral events during animal locomotion from time series data
- *Modelling:* Fitted behavioral models to kinematic data to describe navigation control and decision making during gliding locomotion
- *Machine learning:* used supervised machine learning including multi-variate regression and mixed-effects modelling to identify correlates between the motion features and the observed animal behavior

Marketing and Leadership

- *Marketing:* ran campaign on crowd funding platform Experiment along with public outreach to raise >$3,000 for dissertation research. Campaign resulted in attaining 257 backers leading to recognition a top performer (runner-up: Animal Superpower Challenge)
- *Leadership:* recruited and managed a 7-member interdisciplinary research team to perform behavior and kinematic data collection of flying lizard locomotion in the Agumbe rainforest in India

Junior Research Fellow, Biomechanics Lab, IISc, India

Material fabrication and characterization

- Fabricated biomaterial by enhancing the mechanical and electrical properties of an economically feasible grade of PEDOT:PSS

- Carried out electrospinning and bulk sample preparation of PEDOT:PSS doped with glycerol and PVA.
- Performed industry standard electrical (four probe measurement) and mechanical characterization (uni-axial testing) of fabricated samples.
- The samples showed tenfold increase in conductivity and rubber like properties compared to base PEDOT:PSS, and were compatible with fibroblast cell culture.

Research Internships

May-July 2012	Inflight chases of the housefly *Musca domestica* *Advisor:* Dr. Sanjay P. Sane, National Centre for Biological Sciences, India
Jan-April 2012	A simplistic outlook on the inter-retreat migration and behavioral characteristics of the social spider *Stegodyphus sarasinorum,* *Advisor:* Dr. Hema Somanathan, IISER Trivandrum, India
May-July 2011	A proposed experimental setup to test Zinc incorporation in the cuticle of beetle *Leucophilis lepidophora,* *Advisor:* Dr. Namrata Gundiah, IISc, India
May-July 2010	Resilin elastomeric protein: a characterization study *Advisor:* Dr. Namrata Gundiah, IISc, India