

Curriculum Vitae of Pranav C. Khandelwal

Senior 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 **Research 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**
Indian Institute of Science, India
Advisor: Dr. Namrata Gundiah, [Biomechanics Lab](#)
- 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

*indicates corresponding author

Chellapurath, M.*, **Khandelwal, P. C.**, Schulz, A. K. (2023). Bioinspired Robots Foster Nature Conservation. *Frontiers In Robotics and AI*, (Submitted)

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

*indicates corresponding author

Khandelwal, P. C., Ross, S. D., Dong, H., Socha, J. J.* (2023). Convergence in Gliding Animals: Morphology, Behavior, and Mechanics. [Chapter in press](#) in Convergent Evolution – Animal Form and Function. Eds V. Bels and A. P. Russel. *Springer Link*

Manuscripts in Preparation

Khandelwal, P. C., Zakaria. M., Socha, J. J. (2023). A year at the Forefront of Gliding Locomotion. *Biology Open*, (Invited manuscript)

Khandelwal, P. C., Byrnes, G., Jusufi, A. (2023). Effect of takeoff perturbation during gap crossing in squirrels.

Khandelwal, P. C., Schulz, A., Chellapurath, M., Merker S., Jusufi, A. (2023). Squirrel Slippage Solved through Spiky Scaly Tail.

Khandelwal, P. C., Zakaria. M., Ross, S. D., Socha, J. J., Hedrick, T. L., Jusufi, A. (2023). The role of tail during pitch control in the flying lizard *Draco dussumieri*.

Khandelwal, P. C., Ross, S. D., Socha, J. J. (2023). Gliding in arboreal reptiles. Functional Morphology and Biomechanics of Arboreal Locomotion in Tetrapods. *Springer Nature*, (Invited book chapter)

Published conference abstracts

*indicates undergraduate student mentee; ** indicates presenter

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

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| 2022 | Swiss National Science Foundation, "Soft Paleo-robotics: Recreating Ancient Marine Reptiles' Agile Swimming with Soft Robo-physical Modelling", \$1,000,000 (not funded, co-PI - Dr. Ardian Jusufi) |
| 2022 | Swiss National Science Foundation, "Versa-Tail: Soft biomimetic Limbs enable agile Locomotion Transitions", \$1,500,000 (not funded, PI - Dr. Ardian Jusufi) |
| 2021 | European Research Council Starting Grant, "Deciphering how animals achieve robust locomotion using soft robotics.", \$1,500,000 (not funded, PI – Dr. Ardian Jusufi) |

Awards & Fellowships

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|---------|---|
| 2020 | \$5,000 - Gordan W. and Janice L. Plumbee Summer Research Fellowship |
| 2019 | \$2,500 - Kenan Trust Graduate Student Research Award |
| 2016 | \$250 – 2 nd place in animal superpowers grant challenge |
| 2008-13 | INSPIRE fellowship , awarded by the Government of India |

Teaching experience

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| 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 in 100 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 ([SICB](#))

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 dussumiei* 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. Calibration routine was developed in [easyWand](#)
- *Multi-camera 3D tracking*: implemented 3D tracking using up to 7 GoPro cameras allowing 3D pose estimation of gliding lizards in flight in the jungle (tracking resolution of < 1 cm). The approach save >\$45,000. Tracking routine was developed in [DLTdv](#)
- *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 \$3,487 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