Nicolas J. Deshler

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Interests

I am deeply fascinated by interdisciplinary projects that span the intersection of physics and computer science with an emphasis on optics, computer graphics, and computational imaging. Historically, connections between these disciplines have given rise to rich spaces for scientific exploration and technological development.

Education

- B.A. **Physics and Computer Science**, UC Berkeley (2021)
- Ph.D. **Optics**, U. Arizona (In Progress)

Coursework:
Electrodynamics, Wave/Geometric Optics, Analytic Mechanics, Quantum Mechanics, Machine Learning, Convex Optimization, Signal Processing, Computer Graphics, Data Structures, Computer Architecture, Electrical Engineering, Biophysics, Linear Algebra, Multivariable Calculus, Discrete Mathematics, Information Theory, Probability Theory, Stochastic Processes.

Technical Skills and Qualifications

Programming Languages/Libraries:
- Proficient – **C, C++, Python, Java**, MATLAB, LabVIEW
- Intermediate – **RISC-V** (assembly), GLSL, PyTorch, HTML

Engineering and Lab Work:
- **Prototyping** - 3D printing, laser cutting, breadboarding
- **Electronics** - oscilloscopes, waveform generators, DMMs, Raspberry Pi, Photonic Integrated Circuits

Design and Simulation:
- CAD Programs – Solidworks, Autodesk Fusion 360
- Optical Design – **Zemax OpticStudio**
- CFD Analysis – XFLR5, OpenVSP

Technical Writing and Presentation:
- Extensive involvement in research publication
- Fluent in Spanish (oral and written proficiency)

Featured Research and Industry Experience

Optical Engineering and Signal Processing – (Lockheed Martin, OPCoE & Advanced Technologies Center): *2019-2021*
- Implemented a signal processing chain for a PIC-based interferometric imager (SPIDER).
- Developed theory for multi-baseline interference measurements captured using a PIC architecture with coupled imaging and laser communications capabilities.
- Wrote user-defined surfaces in C for Zemax OpticStudio to facilitate structural and thermal analysis of refractive and reflective optics.
- Generated pipeline for incorporating finite-element data (surface deformation and index gradients) into lens models.

Computational Imaging Research – (Waller Lab, UC Berkeley EECS): *2018-2020*
- Developed a prototype multi-sensor mask-based computational camera for synthetic large-format sensing.
- Adapted reconstruction algorithms and calibration routines to address structured erasures inherent in multi-sensor measurements.
- Built ray-trace simulation pipelines in Python, MATLAB, and Zemax OpticStudio for assessing multi-sensor DiffuserCam performance.

Magnetic Levitation and Optical Engineering – (Whitesides Group, Harvard University Chem): *2017*
- Developed a high-throughput density measurement instrument for cost-effective cell characterization and medical diagnostics.
- Designed a relay lens system to acquire images of magnetically levitated diamagnetic samples for density measurements.
- Prototyped optical assemblies using SolidWorks and 3D printing to realize instrument compatibility with commodity hardware (96-well plates and flatbed scanners).

Bio-Inspired Robotics Research – (Flow Physics and Computation Lab, Johns Hopkins University ME): *2016*
- Studied the aeromechanics of long jumps in crickets as inspiration for novel forms of mechanical locomotion.
- Employed videogrammetry techniques in MATLAB to gather data on limb orientation throughout jump trajectories.
- Analyzed and modelled restoration torques produced by drag forces acting about the center of mass of the insect.

Publications

1. *(Conference Paper):* Zhao E*, **Deshler N***, Monakhova K, Waller L. “Multi-sensor Lensless Imaging: synthetic large-format sensing with a disjoint sensor array”. *Computational Optical Sensing and Imaging 2020 - OSA Technical Digest*. DOI: 10.1364/COSI.2020.CF2C.6
2. *(Journal Publication):* Shencheng Ge, Yunzhe Wang, **Nicolas J. Deshler**, Daniel J. Preston, and George M. Whitesides. “High-Throughput Density Measurement Using Magnetic Levitation”. *Journal of the American Chemical Society 2018.* DOI: 10.1021/jacs.8b01283
3. *(Conference Paper):* Palmer EH, **Deshler N**, Mittal R. (2017) “Aeromechanics of Long Jumps in Spider Crickets: Insights from Experiments and Modeling”. *ASME International Mechanical Engineering Congress and Exposition*, Vol. 7: Fluids Engineering: V007T09A080. DOI: 10.1115/IMECE2017-73498

Patents

1. *(Patent pending):* "Interactive Ultraviolet Decontamination System". Attorney Docket No. SS-01512. (2021)
2. *(Patent pending):* "N-Arm PIC-Based Interferometric Imaging and Communication System". Attorney Docket No. SS-01378. (2020)
3. *(Patent published):* "Sample Analysis with Mirrors". PCT/US2019/032797 (2019)

Awards and Honors

- UC Berkeley EECS representative to NSF's CUR symposium (2018)
- REU awarded by NSF for summer research (2017)
- RAHSS awarded by NSF for summer research (2015)
- 1st Place – Boeing/ASME Personal Air Vehicle Competition
- 1st Place – Best Use of Autodesk Fusion 360

Presentations

Deshler N, Zhao E, Monakhova K, Waller L. (July 2020) *Multi-sensor Lensless Imaging: Synthetic Large-format sensing with a Disjoint sensor Array.* Virtual presentation at OSA Imaging and Applied Optics Congress – Computational Optical Sensing and Imaging 2020.

Deshler N, Monakhova K, Waller L. (October 2018) *Augmenting 3D Reconstruction Volumes for Mask-Based Computational Cameras.* Poster presented at the Council of Undergraduate Research's annual symposium in Washington D.C.

Deshler N, Ge S, Whitesides GW. (August 2017) *Measuring Densities Using Magnetic Levitation.* Final presentation as part of NSF's Research Experiences for Undergraduates (REU) program at Harvard University, John A. Paulsen School of Engineering and Applied Sciences; Cambridge, Massachusetts.

Deshler N, Patel A, Taghizadehasl K, (March 2017) *TriFlight's Personal Air Vehicle (PAV) Design.* Design presentation at the American Society of Mechanical Engineers PAV Competition. Design reviews by Boeing and SkyRyse; Berkeley, California.

Palmer EH, **Deshler N**, Gorman D, Neves C, Mittal R. (November 2015). *Aeromechanics of the Spider Cricket Jump: How to Jump 60+ Times Your Body Length and Still Land on Your Feet.* Poster session presented at the annual conference of the American Physical Society, Division of Fluid Dynamics; Boston, Massachusetts.

Palmer EH, **Deshler N**, Mittal R. (August 2015) *The Aeromechanics of Spider Crickets.* Final presentation as part of NSF's Research Experiences for Undergraduates (REU) program at Johns Hopkins University, Whiting School of Engineering; Baltimore, Maryland.

Projects and Research Descriptions:

Irradiance Modelling, Validation, and Analysis of an Ultraviolet Decontamination Chamber – Lockheed Martin, Optical Payloads Center of Excellence (2020-Present)
The single-use model for Personal Protective Equipment (PPE) in midst of the COVID-19 pandemic has placed serious strain on global supply chains causing a shortage of N95 masks in the United States. In this project, we developed a high-throughput ultraviolet (UV) decontamination chamber for enabling mask reusability. Our development approach was unique in that it introduced light transport software in the design process for the chamber. Most existing ultraviolet decontamination systems neglect light modelling and consequently administer insufficient UV doses (radiant energy per unit area) due to shadowing effects. We simulate and validate the irradiance distributions over the surface of N95 masks to ensure that the appropriate UV dose is delivered. I generated theoretical irradiance models for the cabinet interior, defined an experimental validation protocol for verifying simulated and theoretical irradiance models, and solved issues of measurement discrepancy arising from the angular response differences between digital radiometers and photochromic dosimeters. Additionally, I showed the mathematical effect placing bulk scattering media over irradiance detectors which I later used for properly calibrating the photochromic detectors and mapping color space triplets to a specific dosage.
Mentors:
Jim Hawley (Principal Electro-Optical Engineer), Andrew Cheng (Senior Staff Optical Engineer), Don Polensky (Senior Staff Systems Engineer), Jared Van Cor (Senior Staff Electro-Optical Engineer)

Interferometric Imaging and Signal Processing for SPIDER – Lockheed Martin Advanced Technology Center (2019-Present)
Traditional lensed optical imaging systems suffer from two physical constraints: The diffraction limit and cubic SWAP growth. SPIDER BEMA is a computational imaging system that aims to circumvent these classical constraints by conducting spatial interferometry on a photonic integrated circuit (PIC) – a step towards the realization of flat-panel architectures for telescopic imaging. In this project, I wrote portions of the signal processing chain for SPIDER BEMA's raw measurements in MATLAB. Complex visibility terms (2D Fourier coefficients) are first extracted from a series of temporal scans through interference fringes collected for different baselines on the PIC. Using compressed sensing and convex optimization techniques, this sparse sampling of the scene's Fourier transform is then used to reconstruct the original

image. The signal processing pipeline also necessarily integrates calibration data surrounding the spectral throughput of the imager, non-linearities in the Optical Path Length (OPL) modulation mechanism, and ambient noise.
Mentors:
David Theil (Research Science Manager), Guy Chriqui (Senior Staff Research Scientist), Sam T. Thurman (Senior Staff Research Scientist), Zachary DeSantis (Senior Staff Research Scientist)

Structural-Thermal Optical Performance (STOP) Analysis for Optical Payloads – Lockheed Martin Optical Payloads Center of Excellence. (2019-Present)
Space-based systems must endure a vast range of thermal conditions throughout their orbit. While thermal isolation mechanisms are present on virtually every satellite, optical payloads are particularly vulnerable to thermal variation due to certain design constraints. Furthermore, luminescent and radiated power incident on the optical components is highly dependent on the scene being imaged and contributes to internal temperature variations in the optics. I created a User-Defined surface type compatible with modern ray-tracing software (Zemax OpticStudio) that accurately models arbitrary refractive index gradients and surface sag profiles. These two temperature-dependent parameters are instrumental to the performance of an imaging system. Thus, the functionality of the software extension I developed allows optical engineers to quickly assess how robust their designs are to temperature changes and stress loadings.
The mathematical models for the 3D refractive index and the surface sags are particularly well-suited for conducting STOP analysis with data generated from finite-element methods.
Mentors:
Todd Kvamme (Senior Staff Program Manager), Andrew Cheng (Senior Staff Optical Engineer), Torben Andersen (Senior Staff Optical Engineer), Mike Jacoby (Senior Staff Mechanical Engineer)

Computational Imaging, Waller Lab - UC Berkeley (2018-2020)
Mask-based computational cameras are uniquely capable of recovering 3D information from a single multiplexed 2D sensor measurement. This research seeks to augment the 3D reconstruction volumes of mask-based cameras by employing multi-sensor arrays to synthesize an enlarged sensing area. Under this objective, my work has primarily addressed theory, simulation, and prototyping. I derived a guiding mathematical model motivating our exploration of large-sensor platforms within a ray-optics framework. Improvements predicted by our model include enhanced voxel resolution and extended depth-of-field for 3D reconstruction volumes. I also wrote data pipelines that interface MATLAB and Python with Zemax OpticStudio to explore the design space for sensor arrays. These pipelines characterized design performance by comparing simulated 3D scenes and measurements with the corresponding reconstructions. Informed by these simulated heuristics, we developed a prototype camera featuring a 2x2 sensor array which successfully recovers wide-field images with merely 8.6% of the data required for a conventional lensed system. To achieve this, I adapted existing DiffuserCam reconstruction algorithms and calibration methods to address structured erasures inherent in multi-sensor measurements.
Mentors: Laura Waller (Optical Engineering Professor, UC Berkeley EECS), Kristina Monakhova (Graduate Student, EECS Dept. UC Berkeley)
Websites:
https://github.com/NicoDeshler/Multi-Sensor-DiffuserCam
https://github.com/NicoDeshler/Prototype-DiffuserCam
Publications:
https://www.osapublishing.org/abstract.cfm?uri=cosi-2020-CF2C.6&origin=search

Image Processing: EarthQWaze IBM CGIU Code and Response Hackathon (2019)
For first responders, efficiently accessing disaster-stricken areas with terrestrial vehicles poses a major challenge. During this 36-hour hackathon project we developed a satellite image processing pipeline for directing response teams through roadway networks damaged by natural disasters. Using a combination of image processing techniques and Google's Maps API, we isolated roadways from an input satellite image. We then trained a machine learning model hosted on IBM Watson Cloud to classify the degree of destruction sustained by different regions of the roadways. The outputs of this automated damage-assessment tool are subsequently used to generate an undirected weighted graph. The weight of each edge in this graph represents the time-cost associated with traversing a road based on the damages it sustained. This graph representation of the affected roadway network allows us to conduct a least-time search and identify the ideal path for first responders to access a specific destination quickly.
Mentors:
Tim Robinson (IT Specialist, IBM)
Websites:
https://github.com/NicoDeshler/IBM-Disaster-Response-Hack/

MagLev Instrumentation for Density Analysis, Whitesides Group - Harvard University Chemistry and Chemical Biology (2017 - REU)
Magnetic Levitation (MagLev) of biological samples in a paramagnetic solution has been used to perform density-based characterizations of cells and to conduct medical diagnostics. In this work, we developed a cost-effective MagLev instrument for measuring densities across a broad collection of assay types in a high-throughput fashion. The efficiency and versatility of this instrument stems from its compatibility with standardized assay equipment (i.e. a 96-well plate) and consumer-level flatbed scanners. Using CAD modelling in Solidworks and rapid prototyping technology (i.e. 3D printers and laser cutters) I designed the optical hardware for our device. Specifically, I created the optical assembly as a grid of collinear relay lenses and planar mirrors. This component transmits an orthogonal in-focus view of levitated samples to the surface of a flatbed scanner, enabling data acquisition. In addition, I supported writing image processing programs in MATLAB for analyzing

levitation data to discern sample densities. In practice, this affordable and simple platform could bring point-of-care medical diagnostics to regions facing serious endemics.
Mentors:
Professor George M. Whitesides (Professor, Department of Chemistry and Chemical Biology Harvard), Dr. Shencheng Ge (Post-Doc, Department of Chemistry and Chemical Biology Harvard)
Publications:
https://pubs.acs.org/doi/10.1021/jacs.8b01283

AeroSpace Design - American Society of Mechanical Engineers (UC Berkeley Chapter) Personal Air Vehicle Competition. (2017)
Compact Personal Air Vehicles (PAV) pose a unique solution to the limitations of modern transportation in urban settings. We designed a single-passenger Vertical Take-Off and Landing (VTOL) aircraft, largely inspired by multi-rotor platforms, to meet and exceed the design competition's target performance requirements. By integrating the propulsion mechanics of a multirotor with the lifting properties of a wing, the proposed aircraft design maximizes range and efficiency. Simultaneously, it provides sufficient hovering maneuverability to navigate obstacle-dense landscapes. Technical features that enhance the aircraft's performance include 1) a mid-wing pivot for low-strain transitions between flight modes and 2) a thrust-vectoring exhaust module for improved maneuverability and efficiency in hover. We modelled the aircraft and its mechanics using Autodesk Fusion 360 and OpenVSP. Subsequently we assessed and optimized the flight characteristics of the model by analyzing fluid flow simulations conducted in Autodesk CFD and XFLR5. In practice, this concept vehicle could ease traffic congestion, shorten commute times, and reduce the carbon footprint of urban spaces.
Mentors:
Howard McKenzie (Director of 777 Engineering Division, Boeing), Jeff Lee (Program Manager, Autodesk Education Team)

Bio-Inspired Robotics: Poly-PEDAL Lab, UC Berkeley Integrative Biology Dept. (2017)
Burrowing animals, including razor clams, nightcrawlers, and ghost crabs, exhibit unique fossorial techniques for penetrating the granular media they inhabit. These techniques are evolutionarily optimized to exploit certain mechanical properties of different media while expending minimal energy. Inspired and guided by these locomotive feats, we sought to develop a biomimetic burrowing robot outfitted to assess natural and human-made geological hazards.
Mentors:
Professor Robert Full (Professor, Department of Integrative Biology UC Berkeley), Dr. Benjamin McInroe (Post-Doc, Department of Integrative Biology UC Berkeley)

Bio-Inspired Research: Fluid Dynamics and Flow Physics and Computation Lab, Johns Hopkins Mechanical Engineering. (2015 - RAHSS)
Jumping is a distinct form of locomotion that spans both the aerial and terrestrial domains. In this research, we investigated the aeromechanics governing stable insect jump trajectories, specifically for spider crickets. These insects jump impressively long distances in proportion to their size yet consistently land upright. Using 3-dimensional videogrammetry methods, we tracked and plotted the cricket's center of mass (CoM) and limb positions over the course of its jump trajectory. We then developed MATLAB programs to compute drag force vectors acting on each component of the insect as well as the net torque acting about its Center of Mass from the jump data. These analyses indicated that the cricket's aerial posture generates restoring torques when perturbed. The stabilizing posture prominent in the descent period of the jump trajectory could be vital to successfully replicating this form of locomotion in robotic systems.
Mentors:
Professor Rajat Mittal (Professor, Department of Mechanical Engineering Johns Hopkins University), Emily Palmer (Undergraduate Mechanical Engineering student, Johns Hopkins University).
Publications:
https://asmedigitalcollection.asme.org/IMECE/proceedings-abstract/IMECE2017/58424/V007T09A080/265379

IB Extended Essay: Investigating the Effects of Wingtip Feathers on Induced Drag Reduction and Wing Efficiency. (2014-2016)
The aerodynamic efficiency of soaring birds can be accredited, in part, to a distinct anatomical feature of their wing: Primary feathers. In this project, I investigated how primary feathers influence wingtip vorticity and induced drag by experimentally measuring aerodynamic forces and conducting flow-physics simulations. Using a home-built wind tunnel and a modular base wing, I measured aerodynamic lift and drag for a series of feather profiles and angles-of-attack (AOA). The ratio of these force measurements quantitatively characterized the efficiency of the wing configuration. To establish reliable baselines, I performed flow simulations using XFLR5 on comparable virtual wings. These baselines corroborated the experimental values acquired using the wind tunnel.
Mentors:
Mr. Tony Godwin (Upper School Physics Teacher, Washington International School), Professor. Rajat Mittal (Professor, Department of Mechanical Engineering, Johns Hopkins University).

References:

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