

RESEARCH  
SUMMARY

I work in computational imaging, where we combine illumination, cameras and computation in innovative ways to sense the environment in a way that traditional cameras can't. I currently [build optical imaging systems](#) that use the wave nature of light to achieve exciting capabilities like [seeing through scattering media](#) and [micron-scale shape acquisition](#), with applications in biomedical imaging and fabrication. Some of these are possible only [in the lab](#) now: We're bringing them [out in the open](#)!

RESEARCH  
INTERESTS

Going forward, I would like to explore biomedical optics in the context of both optical imaging and optogenetics. I am especially interested in developing high-resolution optical imaging systems for *in vivo* diagnostics and functional imaging; and establishing computational methods to interpret the data acquired by these systems. Additionally, I am interested in applications of such systems in neuroscience research and their potential to study, monitor and control neurological conditions such as epilepsy.

EDUCATION

**School of Computer Science, Carnegie Mellon University** *Aug 2017 – present*  
PhD in Robotics (ongoing)  
**Electrical Engineering, Indian Institute of Technology Bombay** *Jul 2012 – Jun 2017*  
Dual Degree (Bachelor & Master of Technology)

RESEARCH  
EXPERIENCE

**Computational interferometric imaging** [PhD thesis]  
Prof. Ioannis Gkioulekas, Robotics, Carnegie Mellon University *Aug 2017 – present*

- Explored interferometry with light sources having specially designed wave-optics properties for micron-scale computational light transport, with applications to [optical biomedical imaging](#)
- Built a [prototype full-field interferometer](#) on an optical table demonstrating spatially-gated and pathlength-resolved imaging; and specialized it to descattering and ballistic light path imaging
- Specialized the above to implement fast, full-field, [micron-resolution depth estimation](#) for applications in precision fabrication and high-resolution inspection of critical parts in industry
- Demonstrated interferometry with naturally-available illumination, such as [sunlight](#), to achieve the above capabilities passively, in the face of outdoor conditions such as vibrations and ambient light

**Optimizing acquisition for a static X-ray computed tomography system** [paper]  
Dr. Rajiv Gupta, Neuroradiology, Massachusetts General Hospital *May 2019 – Jul 2019*

- Explored reconstruction and acquisition optimization methods for a novel portable static X-ray CT system with a circular arrangement of low-power X-ray sources around the patient
- Shadowed radiologists in the hospital to understand the process of diagnosing disorders in patients

**A Bayesian framework for laparoscopic image enhancement** [paper, code], [paper, code]  
Prof. Suyash Awate, Computer Science, IIT Bombay *Jan 2015 – Jun 2017*

- Solved a Bayesian optimization problem to undo the detrimental effects of surgical smoke, specularities and noise on laparoscopy images for better visualization and instrument tracking
- Incorporated a novel, learned, histogram-based prior on color channels to restore color contrast in the presence of smoke, and a dictionary-based model for reconstruction in the presence of specularities

**Optimizing sensing for compressed sampling recovery** [Master's thesis, code]  
Prof. Ajit Rajwade, Computer Science, IIT Bombay *Dec 2015 – Jun 2017*

- Designed physically-realizable compressive acquisition and patch-wise reconstruction for existing compressive cameras using a novel circularly-symmetric coherence criterion
- Empirically analyzed the looseness of various reconstruction error bounds and proposed a sampled average-case error design criterion with a proof-of-concept implementation

**Estimating cosmological photometric redshifts with machine learning** [code]  
Prof. Robert Brunner, Astrophysics, Univ. of Illinois at Urbana-Champaign *May 2014 – Aug 2014*

- Developed a novel learning-based method for estimating pixel-wise redshifts in the spectra and distances of dim, faraway astrophysical sources imaged by the Sloan Digital Sky Survey
- Implemented overlapping source separation and classification into galaxies, stars and quasars

PUBLICATIONS UNDER REVIEW	Passive micron-scale time-of-flight with sunlight interferometry [ <a href="#">pre-print</a> ] <b>A. Kotwal</b> , A. Levin and I. Gkioulekas
	Swept-angle synthetic wavelength interferometry [ <a href="#">pre-print</a> ] <b>A. Kotwal</b> , A. Levin and I. Gkioulekas
JOURNAL PUBLICATIONS	Interferometric transmission probing with coded mutual intensity ACM Transactions on Graphics, 2020 [ <a href="#">link</a> , <a href="#">video</a> ] <b>A. Kotwal</b> , A. Levin and I. Gkioulekas
	Joint desmoking, specular removal, and denoising of laparoscopy images via Bayesian inference International Symposium on Biomedical Imaging, 2017 [ <a href="#">link</a> ] A. Baid, <b>A. Kotwal</b> , R. Bhalodia, and S. Awate
CONFERENCE PUBLICATIONS	Joint desmoking and denoising of laparoscopy images International Symposium on Biomedical Imaging, 2016 [ <a href="#">link</a> ] <b>A. Kotwal</b> , R. Bhalodia and S. Awate
	Designing constrained projections for compressed sensing: mean errors and anomalies with coherence IEEE Global Conference on Signal and Information Processing, 2018 [ <a href="#">link</a> ] D. Shah, <b>A. Kotwal</b> and A. V. Rajwade
TECHNICAL SKILLS	<b>Prototyping imaging setups on an optical table</b>
	<b>Programming:</b> Python & Matlab (fluent)   Java, SQL, Verilog & C/C++ (intermediate) <b>Software packages:</b> Zemax OpticStudio, Lumerical, PyTorch, NumPy, SciPy, pandas, scikit-learn <b>Embedded platforms:</b> FPGAs, Raspberry Pi, Arduino
SELECTED COURSEWORK	Introductory Biology, Human Physiology, Nano-Bio-Photonics, Computational Imaging, Physics-based Methods in Vision, Computer Vision, Statistics, Convex Optimization, Machine Learning
OTHER PROJECT EXPERIENCE	<b>Optimizing nanoparticles for efficient photothermal therapy</b> <i>March 2020 – May 2020</i> – Studied nanoplasmonics for photothermal therapy to drive tumor apoptosis in cancer treatment – Performed FDTD simulations in the Lumerical wave equation solver to obtain the optical properties of gold nanoparticles of various parameterized shapes in response to laser irradiation – Optimized energy absorption sequentially over wavelength and nanoparticle shape parameters
	<b>IIT Bombay Mars Rover project</b> <i>Dec 2012 – Jun 2017</i> – Designed, manufactured and assembled the electronics for rover and robotic arm mobility – Developed the communication and control software for rover operation and piloted it in tests – Participated in a simulated Mars mission consisting of various activities, such as sample collection, geology studies and rigorous rover testing on a challenging dry river bed in the Australian outback
	<b>Super-resolution with Fourier ptychographic microscopy</b> <i>Nov 2014 – Jan 2015</i> – Prototyped a Fourier ptychography system to examine histology sections in an eye hospital
	<b>Star variability analysis to detect exoplanets in NGC2419</b> [ <a href="#">report</a> , <a href="#">code</a> ] <i>Dec 2015</i> – Obtained, corrected and analyzed CCD images of the globular cluster NGC2419 to estimate star brightness variability and locate microlensing events indicative of the presence of exoplanets
	<b>An X-ray study of black hole candidate X Norma X-1</b> [ <a href="#">report</a> ] <i>Dec 2013</i> – Estimated the temperature and luminosity of an X-ray binary star system suspected to contain a black hole by fitting X-ray spectra, considering emission processes and line-of-sight absorption
	<b>16-bit pipelined RISC processors on an FPGA</b> [ <a href="#">code</a> , <a href="#">code</a> ] <i>Jul 2014 – Nov 2014</i> – Designed in Verilog and implemented on FPGAs RISC processors based on two architectures