

RESEARCH  
INTERESTS

I work in computational imaging, where we combine illumination, cameras and computation in innovative ways to sense the environment in a way that a 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](#)!

I look forward to applying my research in interferometry to real-life depth sensing and imaging situations, and exploring related fields such as computational displays and holography in the future.

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 light transport with interferometry** [PhD thesis] [[paper](#), [webpage](#)]  
Prof. Ioannis Gkioulekas, Robotics, Carnegie Mellon University *Aug 2017 – present*

- Exploring interferometry with light sources having specially designed wave-optics properties for micron-resolution computational light transport, with applications to [optical biomedical imaging](#)
- Built a prototype interferometer on an optical table demonstrating spatially-gated and pathlength-resolved imaging and specialized it to descattering and direct-only light path imaging
- Extended the above work to implement fast, wide-field, micron-scale depth estimation, currently trying a deep learning-based pipeline for robust depth estimation and phase unwrapping
- Currently experimenting with everyday light sources to achieve the above capabilities passively, incorporating the detrimental effects of real-life 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](#), [paper](#), [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

JOURNAL PUBLICATIONS	Swept-angle synthetic wavelength interferometry To be submitted to ACM Transactions on Graphics [ <a href="#">slides</a> ] <b>A. Kotwal</b> , A. Levin and I. Gkioulekas
	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
	Signal sensing and reconstruction for a novel multi-source static computed tomography system IEEE International Conference on Acoustics, Speech and Signal Processing, 2020 [ <a href="#">link</a> ] <b>A. Kotwal</b> , A. Cramer, D. Wu, K. Yang, W. Krull, I. Gkioulekas and R. Gupta
OTHER PROJECT EXPERIENCE	<b>IIT Bombay Mars Rover project</b> <span style="float: right;"><i>Dec 2012 – Jun 2017</i></span> <ul style="list-style-type: none"> <li>– Designed, manufactured and assembled the electronics for rover and robotic arm mobility</li> <li>– Developed the communication and control software for rover operation and piloted it in tests</li> <li>– 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</li> </ul>
	<b>Super-resolution with Fourier ptychographic microscopy</b> <span style="float: right;"><i>Nov 2014 – Jan 2015</i></span> <ul style="list-style-type: none"> <li>– Prototyped a Fourier ptychography system to examine histology sections in an eye hospital</li> </ul>
	<b>Star variability analysis to detect exoplanets in NGC2419</b> [ <a href="#">report</a> , <a href="#">code</a> ] <span style="float: right;"><i>Dec 2015</i></span> <ul style="list-style-type: none"> <li>– 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</li> </ul>
	<b>An X-ray study of black hole candidate X Norma X-1</b> [ <a href="#">report</a> ] <span style="float: right;"><i>Dec 2013</i></span> <ul style="list-style-type: none"> <li>– 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</li> </ul>
	<b>A 16-bit pipelined RISC processor on an FPGA</b> [ <a href="#">code</a> , <a href="#">code</a> ] <span style="float: right;"><i>Jul 2014 – Nov 2014</i></span> <ul style="list-style-type: none"> <li>– Designed in Verilog and implemented on FPGAs RISC processors based on two architectures</li> </ul>
SELECTED COURSEWORK	Computer Vision, Physics-based Methods in Vision, Statistics, Convex Optimization, Machine Learning, Biology, Human Physiology
TECHNICAL SKILLS	<b>Prototyping imaging setups on an optical table</b> <b>Programming:</b> Fluent Python & Matlab   Intermediate Java, SQL & Verilog   Beginner C/C++ <b>Software packages:</b> ROS/Gazebo, PyTorch, scikit-learn, pandas, Astropy, NumPy, SciPy <b>Embedded platforms:</b> FPGAs, Raspberry Pi, Arduino
AWARDS	Undergraduate Research Award for Master's thesis, Indian Institute of Technology Bombay, 2017 Gold medal at the 6 <sup>th</sup> International Olympiad on Astronomy and Astrophysics, representing India Bronze medal at the 5 <sup>th</sup> International Earth Sciences Olympiad, representing India KVPY Scholarship 2011 by the Government of India for students interested in basic sciences