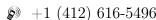
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Research Summary

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 light transport with interferometry

[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 [pre-print]

A. Kotwal, A. Levin and I. Gkioulekas

Swept-angle synthetic wavelength interferometry [pre-print]

A. Kotwal, A. Levin and I. Gkioulekas

JOURNAL PUBLICATIONS Interferometric transmission probing with coded mutual intensity

ACM Transactions on Graphics, 2020 [link, video]

A. Kotwal, A. Levin and I. Gkioulekas

CONFERENCE PUBLICATIONS International Symposium on Biomedical Imaging, 2017 [link]

A. Baid, A. Kotwal, R. Bhalodia, and S. Awate

Joint desmoking and denoising of laparoscopy images

International Symposium on Biomedical Imaging, 2016 [link]

A. Kotwal, 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 [link]

D. Shah, A. Kotwal and A. V. Rajwade

TECHNICAL SKILLS

Prototyping imaging setups on an optical table

Programming: Python & Matlab (fluent) | Java, SQL, Verilog & C/C++ (intermediate)

Software packages: Zemax OpticStudio, Lumerical, PyTorch, NumPy, SciPy, pandas, scikit-learn

Embedded platforms: 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

Optimizing nanoparticles for efficient photothermal therapy

March 2020 - May 2020

- 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

IIT Bombay Mars Rover project

Dec 2012 - Jun 2017

- 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

Super-resolution with Fourier ptychographic microscopy

Nov 2014 - Jan 2015

- Prototyped a Fourier ptychography system to examine histology sections in an eye hospital

Star variability analysis to detect exoplanets in NGC2419 [report, code]

 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

An X-ray study of black hole candidate X Norma X-1 [report]

Dec 2013

- 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

16-bit pipelined RISC processors on an FPGA [code, code]

Jul 2014 - Nov 2014

- Designed in Verilog and implemented on FPGAs RISC processors based on two architectures