Alankar Kotwal

Research Interests

I am passionate about Medical Vision, Robots in Surgery, Computational Imaging & Optics, Estimation, Learning, Optimization, Astrophysics and Cosmology. I also like Networks and Graphics.

Education

Indian Institute of Technology Bombay, Mumbai, India — *July 2012 – Present*

Fifth Year, Dual Degree (Bachelor & Master of Technology), Department of Electrical Engineering
Specialization: *Signal Processing*, **CGPA: 8.96/10.00**, Minor: *Computer Science and Engineering*

Publications

- Baid, A., Kotwal, A., Bhalodia, R., Awate, S., *Joint Desmoking, Despeckling, and Denoising of Laparoscopy Images via Graphical Models with Variational Bayesian Expectation Maximization*. Submitted to the 14th International Symposium on Biomedical Imaging (2017).
- Kotwal, A., Rajwade, A. V., *Optimizing Codes for Source Separation in Compressed Video Recovery and Color Image Demosaicing*. Submitted to the 42nd International Conference on Acoust., Speech and Signal Processing (2017). Paper here, preprint: arXiv:1609.02135 [cs.CV].
- Kotwal, A., Bhalodia, R., Awate, S., *Joint Desmoking and Denoising of Laparoscopy Images* (oral), Proc. of the 13th International Symposium on Biomedical Imaging (2016). Paper here.
- Clarke, J. *et al.*, *Field Robotics, Astrobiology and Mars Analogue Research on the Arkaroola Mars Robot Challenge*, Proc. of the 14th Australian Space Research Conference 2014. Paper here.

Research Internships

The AIR Lab, Carnegie Mellon University Robotics Institute
Guide: Prof. Sebastian Scherer & Stephen Nuske — *Summer 2015*

Stereo Odometry from a Downward-facing Stereo Camera on an Aerial Vehicle

- Developed correlation-based tracking for aerial vehicles with a downward-facing stereo camera
- Estimated height, orientation using a robust homography fit between stereo pairs, position with rigid tracking, achieved better speed and height ranges than the Pixhawk camera without an inertial unit

Laboratory for Cosmological Data Mining, University of Illinois, Urbana–Champaign
Guide: Prof. Robert Brunner, under Google Summer of Code — *Summer 2014*

A Pixel-Level Machine Learning Method for Calculating Photometric Redshifts

- Classified sources into galaxies, stars and background based on broad-band pixel flux
- Worked on creating an image extraction, alignment, cleaning, segmentation and learning pipeline on SDSS images and on performance improvement and got a reasonably good error rate

Srujana – Center for Innovation, L. V. Prasad Eye Institute
Guide: Ashutosh Richhariya, Ophthalmic Biophysics, LVPEI — *Winter 2014*

Super–Resolution with Fourier Ptychographic Microscopy

- Worked on understanding and implementing Fourier Ptychographic Microscopy for microscopy slides
- Analyzed possible extensions of this method to imaging reflective surfaces like the eye

Research Projects

A New Bayesian Framework for Laparoscopic Image Dehazing and Denoising
Guide: Prof. Suyash Awate, CSE, IITB — *January 2015 – Present*

- Developed a Bayesian inference problem for jointly undoing the effect of surgical smoke, specularities and noise on laparoscopy images for better contrast and post-processing (like instrument tracking)
- Tested this method extensively on simulated and real images yielding significant improvement over state of the art dehazing algorithms in terms of numerical and perceptual accuracy

Optimizing Sensing Matrices for Compressed Sampling Recovery — *Master's Thesis*
Guide: Prof. Ajit Rajwade, CSE & Prof. V. Rajbabu, EE, IITB — *December 2015 – Present*

- Studied applications of the principles of compressed sensing to video for compression along time
- Relaxed the need for a dictionary on space and time and strictly smooth motion using a source–separation approach and designed positive sensing matrices with low mutual coherence for this
- Currently optimizing general sensing matrices using error bounds verifiable in polynomial time

The IITB Mars Rover Project — *May 2013 – Present*

- Building a prototype Mars rover capable of extra-terrestrial robotics with a rocker-bogie suspension
- Designed circuits for on-board control and interfaced peripherals, currently developing localization and autonomous navigation and exploring he role of machine vision for automating rover operations
- Participated in a simulated Martian expedition in the Australian outback, at the Arkaroola Mars Robot Challenge and at the Mars Society's Mars Desert Research Station, Utah

Course Projects

Improved Methods for Compressed Sensing Recovery *CS709: Convex Optimization*
Guide: Prof. Ganesh Ramakrishnan, CSE, IITB *Autumn 2015-16*

Using convex approximations to the compressed sensing recovery problem, we reconstructed near-exact versions of images at extremely low compressions, with proofs of correctness. Code here.

Hidden Markov Model Part-of-Speech Tagging *EE638: Estimation and Identification*
Guide: Prof. Navin Khaneja, EE, IITB *Autumn 2015-16*

We implemented part-of-speech tagging with support for unknown words. An error rate of around 5% and capabilities of the system to discern context were observed.

Laparoscopic Image Dehazing with Dark Channel Prior *CS736: Medical Image Processing*
Guide: Prof. Suyash Awate, CSE, IITB *Spring 2014-15*

We applied the Dark Channel Prior method for landscape image dehazing to surgical smoke–affected laparoscopic images, accelerated it in time and got good results.

Stereo Odometry via Point Cloud Registration *CS763: Computer Vision*
Guide: Prof. Ajit Rajwade, CSE, IITB *Spring 2014-15*

Maximizing kernel density correlation with gradient-ascent and coherent point drift, we registered pointclouds and observed good convergence behavior for small transformations.

Gravitational Lens Separation with PCA *CS663: Digital Image Processing*
Guide: Prof. Suyash Awate & Prof. Ajit Rajwade, CSE, IITB *Autumn 2014-15*

Lensed images of galaxies have rare arc-like artifacts that can be used to calculate the mass of the lens. We used Anscombe denoising followed by PCA to subtract sources and detect arcs.

Astrophysics Projects

Detection of Short Gamma-ray Bursts from Astrosat Data *PH426: Astrophysics*
Guide: Prof. Vikram Rentala, PH, IITB *Spring 2015-16*

Among the open problems and new datasets in the field, we tackle detecting short gamma-ray bursts from data acquired by the CZTI Hard X-Ray Imager on board the Astrosat.

Processing and Inference from CCD Images *NIUS, Astronomy*
Guide: Prof. Priya Hasan, MANUU, Hyderabad *December 2015*

We analyzed raw data for the globular cluster NGC2419 taken at the HCT, post-processed it and extracted the variation of magnitudes of stars in the cluster on the scale of a day. Code here.

An X-Ray Study of Black Hole Candidate X Norma X-1 *NIUS, Astronomy*
Guide: Prof. Manojendu Choudhury, Center for Basic Sciences *December 2013*

We analyzed spectral data for the X-Ray Binary 4U 1630-47, in a period that corresponds to an outburst in the source for various system parameters like internal radius, temperature and so on.

Estimation of Photometric Redshifts Using Machine Learning *NIUS, Astronomy*
Guide: Prof. Ninan Sajeeth Philip, IUCAA, Pune *December 2012*

Here, we trained a neural network to calculate photometric redshifts and used SDSS data and its redshifted versions to train it, getting good predictions for redshift.

Achievements and Awards

- Represented India at the 6^{th} International Olympiad on Astronomy and Astrophysics, Brazil, 2012. Won a Gold Medal with International Rank 4 and a special prize for Best Data Analysis
- Represented India at the 5^{th} International Earth Sciences Olympiad, Italy, 2011. Won a Bronze Medal and prizes for best performance in the Hydrosphere section and the team presentation
- Secured All India Rank (AIR) 105 in IIT-JEE amongst half a million candidates
- Awarded KVPY Scholarship 2011 and NTSE Scholarship 2008 by the Govt. of India

Mentoring Experience

Teaching Assistant

CS663: Digital Image Processing	Prof. S. Awate and Prof. A. Rajwade	*Autumn 2015-16*
CS736: Medical Image Processing	Prof. S. Awate	*Spring 2015-16*
EE638: Estimation and Identification	Prof. N. Khaneja	*Autumn 2016-17*

Resource Person, Indian Astronomy Olympiad Programme *May 2013, May 2014*

Involved in mentoring high-school students in Astronomy for their selection to the international Astronomy Olympiads, and in setting up challenging questions and evaluating students.

Technical Skills

Programming	C/C++, Python, Bash, Matlab, Verilog, SQL, HTML, PHP, LaTeX
Software Packages	ROS/Gazebo, OpenCV, The Point Cloud Library
Science Software	Python packages: NumPy, SciPy and Matplotlib, GNUPlot, Scikit-learn
Hardware	Common Microprocessors, CPLDs and FPGAs, Embedded Platforms