Alankar Kotwal

Senior Undergraduate

Research Interests

I am passionate about Computer and Medical Vision, Machine Learning, Optimization, Estimation Theory, Astrophysics and Cosmology. I also like Robotics, Networks & Security and Graphics.

Education

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

Dual Degree, Bachelor & Master of Technology, Department of Electrical Engineering
Specialization: *Communication and Signal Processing*, **CGPA: 8.83/10.00**

Publications

- Kotwal, A., Bhalodia, R., Awate, S., *Joint Desmoking and Denoising of Laparoscopy Images* (oral), Proc. of the International Symposium on Biomedical Imaging, 2016. Paper here.
- Clarke, J. D. A., Held, J. M., Dahl, A. *et al.*, *Field Robotics, Astrobiology and Mars Analogue Research on the Arkaroola Mars Robot Challenge Expedition*, 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 A Vehicle

- Developed correlation-based tracking for aerial vehicles with a downward-facing stereo camera
- Estimated height, pitch and roll jointly using a robust gradient-descent homography fit between stereo pairs, and position with rigid tracking across frames
- Achieved performance comparable to, maximum speeds and height ranges better than the standard Pixhawk PX4FLOW 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 Source Redshifts

- Used broad-band pixel energies from faint sources extracted from SDSS (as a proxy to their entire spectrum) as features for a machine learning algorithm to calculate redshifts
- Accomplished classification of sources into galaxies, stars and background based on pixel features
- 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

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 and noise on laparoscopy images for better contrast and post-processing (like segmentation and 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
- Surveyed laparoscopy experts about quality of our results compared to the existing algorithms and found a statistically significant trend that this method yields superior results

Coded Source Separation for Compressed Video Recovery — *Dual Degree Thesis*
Guide: Prof. Ajit Rajwade, CSE, and Prof. V. Rajbabu, EE, IITB — *December 2015 – Present*

- Studied applications of the principles of compressed sensing to video for compression along time
- Currently trying to relax the requirement of a dictionary on both space and time and the requirement of strictly smooth motion using a source–separation approach to this problem
- Aim to design positive [0, 1]–uniform sensing matrices with low mutual coherence, making them ideal for compressed video using the source–separation approach

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

- Aim to build a prototype Mars rover capable of extra-terrestrial robotics, currently have a rover with a rocker-bogie suspension and novel air-filled beach tires
- Designed power, logic and communication circuits for on-board control and interfaced peripherals for perception and actuation, 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 and Prof. Ajit Rajwade, CSE, IITB *Autumn 2014-15*

Gravitationally 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 build a basis for galaxy images and used the top few eigengalaxies 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

Olympiads and Competitive Exams

- 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 1.1 million candidates

Scholarships

- Awarded KVPY Scholarship 2011 by Dept. of Science and Technology, Govt. of India
- Awarded NTSE Scholarship 2008 by NCERT, Govt. of India

Technical Skills

Programming	C/C++, Python, Bash, Matlab, Verilog, SQL, HTML, PHP, LaTeX
Software Packages	ROS/Gazebo, OpenCV, The Point Cloud Library, SPICE Circuit Simulation, EAGLE PCB Design, SolidWorks, AutoCAD, LabView
Science Software	Python packages: NumPy, SciPy and Matplotlib, GNUPlot, Scikit-learn, Astropy, SExtractor, SDSS tools
Hardware	*Microprocessors:* 8051, 8085, AVR and PIC, CPLDs and FPGAs, *Embedded Platforms:* Arduino, RaspberryPi, *standard digital logic*