Aparajita Sahoo

CONTACT
INFORMATION

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RESEARCH
INTERESTS

I am passionate about creating a social impact by working at the intersection of health technologies, data science, design and social innovation that will impact the lives of the people globally. I am also interested in enhancing user experiences by combining the power of computing, mobile technologies and effective design. I have also worked on electronics prototyping of low cost healthcare devices that can be deployed in rural areas that dont have access to medical facilities.

EDUCATION

Univ. of Mumbai, Fr. Conceicao Rodrigues Inst. of Technology, Mumbai   *2011 – 2015*
Bachelor of Engineering, Electronics and Telecommunication Engineering, *First Class*

Atomic Energy Junior College, Anushaktinagar, Mumbai   *2008 – 2010*
Intermediate Degree, Science with Vocational Training in Electrical Maintenance, *88%*

Atomic Energy Central School, Anushaktinagar, Mumbai   *1998 – 2008*
Matriculation, *93.8%*, *All India Topper in Mathematics*

RESEARCH
EXPERIENCE
AND PROJECTS

REDX Innovation Lab, under **Emerging Worlds Special Interest Group**, **MIT Media Lab**
Innovation Engineer, focusing on healthcare technologies for rural areas

Project: Dermato   ‖   *Guide: Dr. Anshuman J. Das*   ‖   October 2015 – Present
A project aiming to solve important problems faced by dermatologists in diagnosis in rural areas

The first part is a study aimed at reducing the subjectivity in visual examination of skin diseases, especially in depigmented conditions. Here, it is difficult to diagnose similar looking diseases without an intravenous procedure like biopsy. We have developed a non-intravenous method to identify the condition which is much faster, cheaper and less painful than existing methods. The device is a fluorescence spectroscopy test that can be done with the help of a mobile phone. I have been involved in collaborating with doctors to design and implement this study at the K. J. Somaiya Hospital, Mumbai. I have been actively helping doctors to collect data using our device, from around 200 skin patients over a period of 5 months. I have been working on analyzing this data and improving the design and user interface based on feedback from doctors. We plan to publish the results of this study at a prominent healthcare conference.

The second part of the project is a portable mobile clip-on that can be used by dermatologists in visual examination of the skin. This affordable app-based device provides magnified, high quality and polarized images of skin lesions and allows one to annotate, store and access them along with patient data. I was involved in giving inputs for its design and usability. I was involved in a pilot study that included doctors from K. J. Somaiya hospital to test the device on their patients and give us critical feedback of its design and app interface. Its success led us to mass-manufacture the clip-on, to be distributed to about 500 dermatologists in and around Mumbai.

Project: StethoCG   ‖   *Guide: Guy Satat*   ‖   October 2015 – Present
A project aiming to provide better detection of cardiovascular disorders in rural areas

Cardiovascular diseases, among all reasons, cause the maximum number ($\sim$ 1.4 million) of deaths per year in India. Rural areas are especially affected due to a lack of doctors specializing in diagnosis of these disorders. We aimed to solve this problem with a screening device that helps in detecting heart murmurs in patients leading to possible further diagnosis and treatment. The device combines a digital stethoscope and an ECG to identify irregularities in heartbeat. I had developed the hardware prototype which led to better data collection. The user interface of the device designed to be simple for use by a health worker and its form factor was reduced to make it portable. This was used to collect data samples from various patients and the preliminary data was analyzed to detect similarities in their pattern.
This project was *presented to Ratan Tata* and it got positive feedback.

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

Super–Resolution with Fourier Ptychographic Microscopy
The maximum number of independent samples that an imaging setup can extract from the imaged scene is dictated by the limits set by Fourier optics: if the imaged scene is wide–field, there are limits on how much one can zoom in. However, wide–field, high–resolution images are generally desirable in microscopy, pathology and eye imaging. Traditional methods to achieve this, ptychography, for instance, involve mechanical adjustment and require precise control and actuation. Fourier Ptychographic Microscopy was introduced in 2013 as a computational tool to work around this. The idea is to shift, in the Fourier domain, high–frequency information to low frequencies (where the system's optics do not filter it), sense it, and shift it back while reconstructing. We worked on understanding and implementing this method for microscopy slides, and analyzed possible extensions to imaging reflective surfaces like the eye. Code here.

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

Laparoscopic images in minimally invasive surgery get corrupted by surgical smoke and noise. This degrades the quality of the surgery and the results of further processing for, say, segmentation and tracking. Algorithms for desmoking and denoising laparoscopic images seem to be missing in the medical vision literature. We formulated the problem of joint desmoking and denoising of laparoscopic images as a Bayesian inference problem. This formulation relies on a novel probabilistic graphical model of images, which includes a Markov Random Field (MRF) formulation for color-contrast and another MRF for smoothness on the uncorrupted color image as well as the transmission-map image that indicates color attenuation due to smoke. We resort to a mode approximation (using gradient descent) to the Bayesian posterior to estimate the underlying scene. The results on simulated and real-world laparoscopic images, with clinical expert evaluation, shows the advantages of our method over the state of the art. We now extend this framework to include speckle removal, with better optimization techniques like Variational Bayes–based Expectation Maximization. Code here.

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

Recent efforts to apply the principles of compressed sensing to video data involve combining frames into coded snapshots while sensing and separating them with an over–complete dictionary. This works well, but needs a dictionary at the same frame–rate and time–smoothness as the video. We try relaxing this constraint using a source–separation approach to this problem where precise error bounds on recovery have been derived. We designed practically–realizable positive patch–wise sensing matrices that have low mutual coherence in all circular permutations, which facilitates accurate overlapping patchwise recovery. We currently aim to design general sensing matrices with quantities that yield tighter error bounds than the coherence. We thus explore bounds (like the l_1–CSMV and l_∞–based bounds) which 'soften' the sparsity criterion for l_1 recovery, resulting in quantities verifiable in polynomial time, as opposed to the RIC bound which is combinatorial and therefore difficult to optimize. Code here.

The IITB Mars Rover Project   *May 2013 – Present*

The IITB Mars Rover project is a student initiative at IIT Bombay to build a prototype Mars rover capable of extra-terrestrial robotics and to participate in the University Rover Challenge at the Mars Society's Mars Desert Research Station, Utah. The mechanical subsystem designed and developed a rover with a rocker-bogie suspension and novel air-filled beach tires. The electrical and software team designed power, logic and communication circuits for on-board control. Currently, localization and autonomous navigation are being developed. The role of machine vision for automating rover operations is being explored. One of the design goals for the future is to develop the capability to help astronauts on space missions. We participated in a simulated Martian expedition and tested Rover capabilities in the harsh conditions of the Australian outback, at the Arkaroola Mars Robot Challenge. We participated in a series of exercises in Mars Operations Research, involving test extra–vehicular activities in space–suits (a sample collection task and a rover guidance task) conducted by Saber Astronautics. Details and pictures here.

COURSE PROJECTS	**Improved Methods for Compressed Sensing Recovery**	*CS709: Convex Optimization*

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. Code here.

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. Code here.

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. Code here.

Gravitational Lens Separation with PCA   *CS663: Digital Image Processing*
Guide: [Prof. Suyash Awate]() & [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. Code here.

Processor Design   *EE309: Microprocessors*
Guide: [Prof. Virendra Singh](), EE, IITB   *Autumn 2014-15*

We designed, simulated and implemented a multi-cycle RISC processor following the LC-3b ISA. Also, we designed and simulated a pipelined RISC processor using the Little Computer ISA.

ASTROPHYSICS
PROJECTS

Detecting Short γ-ray Bursts in Astrosat CZTI Data   *PH426: Astrophysics*
Guide: [Prof. Vikram Rentala](), PH, IITB and [Prof. A. R. Rao, TIFR, Mumbai]()   *Spring 2015-16*

We did a literature survey on γ-ray bursts, including open problems in the field. We tackle detecting short γ-ray bursts from data acquired by the CZTI X-Ray Imager on-board Astrosat.

Variability Analysis for Globular Cluster NGC2419   *[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 to correct for detector bias and flat-fielding, inverted the effect of atmospheric mass 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 data from the RXTE for a low-mass X-Ray Binary. Fitting 3-30 keV spectra with a model accounting for blackbody & non-thermal radiation, and interstellar extinction, we obtained values of system parameters like internal radius and temperature. Report here.

Estimation of Photometric Redshifts with Machine Learning   *[NIUS, Astronomy]()*
Guide: [Prof. Ninan Sajeeth Philip, IUCAA](), Pune   *December 2012*

Here, we trained a neural network for photometric redshifts, given data for sources whose spectra and redshifts have been measured. We predicted spectra for these objects viewed at various other values of redshifts. Using this expanded dataset, we achieved good predictions for test data.

ACHIEVEMENTS
AND AWARDS

- Represented India at the 6th 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 5th 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 105 in the IIT-JEE 2012 amongst half a million candidates
- Awarded KVPY Scholarship 2011 by Dept. of Science and Technology, Govt. of India
- Awarded NTSE Scholarship 2008 by NCERT, Govt. of India

KEY TALKS AND SEMINARS	**Coded Source Separation for Compressed Video Recovery**	*Master's Thesis Talk*

KEY TALKS AND SEMINARS

Coded Source Separation for Compressed Video Recovery
Master's Thesis Talk
Department of Electrical Engineering, Indian Institute of Technology Bombay
May 2016
Here, I presented results from the first stage of my dual degree thesis. Presentation here.

Template-Based Stereo Odometry
Invited Talk
The AIR Lab, Carnegie Mellon University
July 2015
I presented results of summer internship at CMU. The talk included a detailed description of the method used, comparisons with ground-truth and stress-tests on the method. Presentation here.

The Cosmic Distance Ladder
Invited Talk
Krittika – The Astronomy Club, IIT Bombay
September 2014, February 2016, August 2016
This talk climbs the Cosmic Distance Ladder, a sequence of steps, each building on previous steps' results, for calculating distances in the universe. We begin with solar system distances, and end at enormous distances where the only option is using indirect methods. Presentation here.

MENTORING EXPERIENCE

Teaching Assistant for IITB Courses

CS663: Digital Image Processing	Prof. S. Awate & 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
Selected twice as a resource person for Indian Astronomy Olympiad Camps, to mentor students for their selection to the International Astronomy Olympiads. Involved in mentoring 100-odd high school students in astronomy, and in setting up challenging questions and evaluating them.

KEY COURSEWORK

Computer Sciences and Engineering
Computer Vision, Digital & Medical Image Processing, Machine Learning, Convex Optimization, Graphics, Networks, Data Structures, Design & Analysis of Algorithms, Discrete Mathematics

Electrical Engineering
Estimation & Identification, Adaptive & Digital Signal Processing, Speech Processing, Matrix Computations, Information Theory, Advanced Probability, Communication Networks

Physics and Mathematics
Astrophysics, General Theory of Relativity, Electromagnetic Waves, Electricity & Magnetism, Classical Mechanics, Differential Equations, Linear Algebra, Complex Analysis, Calculus

TECHNICAL SKILLS

Programming	C/C++, Python, Bash, Matlab, Verilog, SQL, HTML/CSS, PHP, LaTeX
Software Packages	ROS/Gazebo, OpenCV, The Point Cloud Library
Science Software	Python packages: NumPy, SciPy and Matplotlib, GNUPlot, Scikit-learn
Hardware	*Microprocessors:* 8051, 8085, AVR and PIC, CPLDs and FPGAs, *Embedded Platforms:* Arduino, Raspberry Pi, NVIDIA Jetson TK1

OTHER INTERESTS

OTHER than my academic interests, I like biking, long walks, trekking, climbing whatever can be climbed, swimming, table tennis, socializing, cooking good food and eating it. I especially enjoy classic rock music & people who enjoy my interests. And finally, I love Origami, the art of paper folding, and building complex, realistic models with Lego blocks.

REFERENCES

Guy Satat, Camera Culture MIT Media Lab | E–Mail | Webpage	**Prof. Ajit Rajwade**, CSE IITB | E–Mail | Webpage
Dr. Sebastian Scherer, Robotics Institute CMU | E–Mail | Webpage	**Ashutosh Richhariya**, Ophthalmic Biophysics LVPEI | E–Mail | Webpage
Prof. Mayank Vahia, Astrophysics TIFR | E–Mail | Webpage	**Dr. Aniket Sule**, Astronomy HBCSE–TIFR | E–Mail | Webpage
Prof. Rajbabu Velmurugan, EE IITB | E–Mail | Webpage	**Dr. Manojendu Choudhury**, Astrophysics UM–DAE CBS | E–Mail | Webpage