Ashish Bora

Contact Information

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Research Interests

I am broadly interested in applications of Probability, Optimization and Algorithms. Specific domains of interest include Machine Learning, Data Mining, Scalable Algorithms for Big Data, Probabilistic Modeling, Stochastic Algorithms and Optimization.

Education

Current March 2015	Indian Institute of Technology Bombay, Mumbai, India *Bachelor of Technology (Honors) in Electrical Engineering* Major GPA : 9.61/10.0 (after 7 semesters) Department Rank 5 in terms of core GPA
Current March 2015	Indian Institute of Technology Bombay, Mumbai, India *Minors in Computer Science and Engineering* Minor GPA : 9.75/10.0

Publications

Ashish Bora, Arjun Rao and Bipin Rajendran, Mimicking the worm - an adaptive spiking neural circuit for contour tracking inspired by C. Elegans Thermotaxis, *International Joint Conference on Neural Networks, IEEE World Congress on Computational Intelligence 2014, Beijing* (http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6889892)

Research Experience

Ongoing	**Rank Preserving Graph Sparsification** Advisor: Prof. Vivek Borkar Department of Electrical Engineering, IIT Bombay, India
Background	Computing node ranking in a graph finds several applications, the most notable being Google's PageRank. Such problems can be huge in size and thus computation of ranking can be extremely expensive. We explore the possibility of designing an adaptive graph sparsification scheme, that compresses the graph by edge deletions while preserving ranks approximately.
Approach and Results	Many popular ranking schemes (such as PageRank, HITS) order the nodes according to top eigenvector of matrices derived from the graph structure. Preserving spectrum then is a good proxy for preserving ranking. Spielman and Shrivastava[2011], show that sampling the edges according to their effective resistances preserves spectrum. We designed two MCMC based schemes to estimate edge resistances. We prove that edge resistances are efficiently PAC learnable using our schemes by deriving corresponding sample complexities. We are working on using eigenvector perturbation theory to obtain compression-accuracy tradeoffs. We also plan to use importance sampling to further improve the edge resistance estimation methods.

MAY 2013- JAN 2014	**Bio-inspired Spiking Neural Networks for 2-D contour tracking** Advisor: Prof. Bipin Rajendran Department of Electrical Engineering, IIT Bombay, India
Background	Humans are incredibly efficient at complex tasks such as face recognition, speech recognition, performing complex maneuvers etc., while being robust to noise and adaptive to dynamic environment. Current artificial systems that try to mimic these capabilities leave a lot to be desired. Spiking Neural Networks (SNNs) closely model the important aspects of biological neural systems and hold a great potential as building blocks for intelligent systems. We seek to demonstrate the power of SNNs by designing a small network to perform two dimensional locomotion control
Approach and Results	C. Elegans is a tiny worm which tends to migrate to regions of favorable temperature. This behavior is called thermotaxis. Laser ablation studies indicate that a small 5-7 neuron network controls thermotaxis in C. Elegans. Using certain known properties of the neurons in this network, we guessed their functions and based on that, designed a dynamics model for exploration and tracking. We then built SNNs to realize different components of this model. Finally, we put them together and tested our model on various noisy temperature profiles using simulations in MATLAB. Results indicate that our neural circuit can identify isotherms with $\sim 60\%$ higher probability than the theoretically optimal memoryless Levy foraging. Further, the model exhibited sparse spiking enabling energy-efficient implementations.

WORK EXPERIENCE

SUMMER 2014	**Fixing Inconsistent Correlation Matrices** Summer Analyst, Controllers Modeling, Finance Division Goldman Sachs, Bangalore, India
Background	An (undisclosed) application involves combining incomplete correlation data from many different sources. Since some sources are more reliable than others, we combine the data giving preference to reliable sources. Such combination leads to inconsistencies, making some principal sub-matrices of the correlation matrix non positive semi-definite. Out of them, some might be of further interest, and we would like to make sure that they are consistent. How do we find the nearest matrix (in terms of Frobenius norm) such that the sub-matrices of interest are ensured to be positive semi-definite?
Approach	We tried a heuristic algorithm that sequentially "fixed" the principal sub-matrices one by one and looped till little change was observed. On the data we had, it seemed to work pretty well. To analyze this algorithm, I modeled the problem using tools from convex geometry and reduced it to finding projection of a given point onto an intersection of finitely many simple, convex, compact sets in an Hilbert Space. The heuristic algorithm turned out to be an instance of alternating projections method, which is guaranteed to converge to a feasible, but possibly non-optimal solution. I deployed Dykstra's Cyclic Projection idea to get an algorithm that provably converges to the optimal solution. I also achieved a 40x speedup by using efficient algorithms for checking positive semi-definiteness.
Autumn 2012	**Textbook Companion Project** Intern, FOSSEE (Free and Open Source Software for Education), IIT Bombay, India This project aims to port examples from standard textbooks using a FOSS system to promote a wider use of FOSS. I completed the porting for the book Basic Electrical Engineering (ISBN: 9780070146112) using Scilab.

ACADEMIC AND TECHNICAL PROJECTS

AUTUMN 2014   **Literature survey on Low Rank Matrix Completion: Alternating Minimization and Incoherence**
Advisor: Prof. Vivek Borkar, Dept. of Electrical Engineering, IIT Bombay

SPRING 2014   **Video stabilization**
Advisor: Prof. Ajit Rajwade, Dept. of Computer Science and Engg., IIT Bombay

- Modeled the unstability as additive high frequency noise
- Estimated a sequence of affine transformations between SIFT feature points of consecutive frames, using least squares fitting
- Applied mean filtering to remove high frequency components, and reapplied the transformations to get stabilization

SPRING 2014   **Markov Decision Processes (MDP) for High Volume Stock Procurement**
Advisor: Prof. K.S. Mallikarjuna Rao, Dept. of IEOR, IIT Bombay

- Given a fixed large amount of stock to be procured, within a stipulated time period, the objective is to devise a trading strategy to minimize the total discounted cost incurred.
- Modeled the relationship between trading volume and stock prices
- Formalized the problem in a MDP framework and subsequently provided algorithms to solve this optimization problem numerically

AUTUMN 2013   **Automatic Traffic Surveillance System using Traffic Videos**
Advisor: Prof. Ajit Rajwade, Dept. of Computer Science and Engg., IIT Bombay

- Achieved adaptive, robust background estimation by online training of a Gaussian Mixture Model
- Achieved moving object detection using background subtraction, thresholding, median filtering, morphological closing and connected component analysis
- Developed an algorithm for predictive tracking of vehicles in the video by clustering instances of same vehicle across frames. Obtained the total number of unique vehicles in the video.

AUTUMN 2013   **Trellis Coded Modulation and Demodulation**
Advisior : Prof. Jayanta Mukherjee, Dept. of Electrical Engineering, IIT Bombay

- Designed architecture for a communication system employing rate 1/2 convolutional code for forward error correction
- Implemented a hard decision Viterbi Decoder on an Intel 8051 based embedded development board

SUMMER 2013   **Solvers for some NP-Hard problems**

- Graph Coloring: Used a combination of Branch and Bound, Constraint Programming and Local Search Techniques
- Travelling Salesman Problem: Used a greedy Heuristic followed k-OPT neighborhood Local Search

SUMMER 2013   **Spam Filter based on a Support Vector Machine**

- SpamAssassin Public Corpus of 9418 emails was used for training and testing
- After using Porter Stemmer for preprocessing, words that occurred more than 10 times in the spam data were used as features
- Trained an SVM to build the classifier. Test set accuracy was 99.8%

SPRING 2013   **LightsOut Game and Solver on a LED Matrix**
Advisors: Prof. M. B. Patil, Prof. Saurabh Lodha, IIT Bombay

- Proved that all configurations are solvable and designed an algorithm that gives the solution from any starting point
- Implemented the game and solver algorithm in Verilog using Quartus IDE
- Extensive optimization to fit the logic on the minimal available hardware

AUTUMN 2011   **Virtual Carom game – using C++**
Advisor: Prof. D. B. Phatak, Dept. of Computer Science and Engg., IIT Bombay

- Designed and implemented the physics engine for the game of carom involving predictive collision mechanics, friction and special handling near holes
- Part of the UI design and implementation team

DISTINCTIONS AND AWARDS

DEC 2013	Received the Undergraduate Research Award for the work on Bio-inspired Spiking Neural Networks
2008	Recipient of the *Maharashtra Talent Search Scholarship* with Rank 8
2007	Recipient of the *National Talent Search Scholarship* awarded to about top 1% applicants
2007	Recipient of the *Maharashtra Talent Search Scholarship* with Rank 10

SCHOLASTIC ACHIEVEMENTS

CURRENT	Department Rank 5 based on GPA in the B.Tech. program in Electrical Engineering
AUTUMN 2014	Scored a perfect Semester Performance Index (SPI) of 10/10
AUTUMN 2012	One of the 6 students allowed Change of Majors to Electrical Engineering in a batch of 880 students based on performance in the first year
SPRING 2012	Awarded an AP (A-plus) grade for exceptional performance in the course *Linear Algebra* given to top 6 out of 849 students
SPRING 2012	Scored a perfect Semester Performance Index (SPI) of 10/10
2011	Secured All India Rank 58 and State Rank 6 in *AIEEE-2011* out of about 1.1 million candidates
2011	Secured All India Rank 400 in *IITJEE-2011* out of about 460,000 candidates
2010	Secured All India Rank 14 in *National Cyber Olympiad 2010*
2006	Secured All India Rank 1 in *National Science Olympiad 2006*

CERTIFICATES

OCT 2014	GRE®: 333/340 Qunatitative: 170, Verbal: 163, AWA: 4
NOV 2014	TOEFL®: 113/120 Reading: 29, Listening: 30, Speaking: 26, Writing: 28

TECHNICAL SKILLS

Programming Languages:	C++, Python, MATLAB, GNU Octave, Julia, Verilog HDL, Assembly
Packages and Tools:	Pratt, MiniZinc (CP Solver), LaTeX, SketchUp, Quartus, LTSpice, Eagle
Libraries and Toolboxes:	scikit-learn, libsvm, pandas, MATLAB Image Processing Toolbox
Micro-controllers:	Arduino, 8085 and 8051 programming

Relevant Coursework

ELECTRICAL ENGINEERING	Signals and Systems, Digital Signal Processing, Speech Processing, Communication Systems, Digital Communications, Network Theory, Control Systems, Electronic Devices, Analog Circuits, Digital Circuits, Microprocessors, Machines and Power Electronics, Power Systems, Electromagnetic Waves
COMPUTER SCIENCE	Data Structures and Algorithms, Discrete Structures, Design and Analysis of Algorithms, Computer Networks, Digital Image Processing, Computer Vision, Machine Learning[†], Neural Networks for Machine Learning[†], Probabilistic Graphical Models[†], Cryptography[†], Quantum Computation[†], Computational Neuroscience[†]
MATHEMATICS	Multivariable Calculus, Data Analysis and Interpretation, Linear Algebra, Differential Equations I and II, Complex Analysis, A First Course in Optimization, Probability and Random Processes, Markov Decision Processes, Introduction to Linear Filtering, Games and Information, Stochastic Optimization, Linear and Integer Programming[†], Discrete Optimization[†]
OTHER	Economics, Philosophy, Electricity and Magnetism
	[†]Online on Coursera or edX

Leadership

ACADEMIC MENTOR	As a member of the Electrical Engineering Department Academic Mentorship Program, responsible for the ensuring healthy academic environment. We have organized numerous structured help and doubt clearing sessions for junior students. I have personally assisted one student and now, he has gained good confidence in academics.
SCIENCE CLUB	In 2008, I founded the School Science Club and spearheaded its operations for over an year. Our goal was to increase awareness about science. We edited and published a weekly wall magazine, conducted science quizzes and invited speakers to conduct sessions to remove superstitions.

Other interests and activities

I like to solve logical puzzles and mathematical problems. Our team stood first in Math and Logic General Championship 2012 open for everyone at IIT Bombay. I was also part of the team that stood first in Electronics General Championship 2013 at IIT Bombay.

I love to listen to music and play acoustic guitar. I haven't taken any formal training, but learnt to play through my friends and the Internet. I performed as a rhythm guitarist in Surbahaar, IIT Bombay's annual musical night.

I like to keep myself updated on scientific advances and geopolitical events. I enjoy reading about evolution, history of human civilization, psychological experiments, astronomical events and space programs. I like to read books on fiction, scientific speculation and entrepreneurship.

I have completed over one year of training with the National Cadet Corps.

REFERENCES

Professor Vivek Borkar
Department of Electrical Engineering, Indian Institute of Technology, Bombay
https://www.ee.iitb.ac.in/web/faculty/homepage/borkar

Professor Bipin Rajendran
Department of Electrical Engineering, Indian Institute of Technology, Bombay
https://sites.google.com/site/rajendranbipin/

Professor Ajit Rajwade
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Professor Bharat Adsul
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