VIKAS CHANDRAKANT RAYKAR

PERSONAL DATA

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RESEARCH INTERESTS

Learning with imperfect supervision (learning from crowds, multiple-instance learning)
Scalable machine learning algorithms for massive datasets
High-dimensional classification, empirical Bayesian inference
Machine learning applied to medical imaging (computer-aided diagnosis), survival analysis

EDUCATION

MAY 2007 Doctor of Philosophy in COMPUTER SCIENCE, University of Maryland, College Park
Thesis: Scalable machine learning for massive datasets: Fast summation algorithms
GPA: 4.0/4.0 | Advisor: Dr. Ramani DURAISWAMI

DEC 2003 Master of Science in ELECTRICAL ENGINEERING, University of Maryland, College Park
Major: Signal Processing | Minor: Computer Engineering
GPA: 3.828/4.0 | Advisors: Dr. Ramani DURAISWAMI and Dr. Rama CHELLAPPA

MAY 2001 Bachelor of Engineering in ELECTRONICS AND COMMUNICATION ENGINEERING
National Institute of Technology, Trichy, India
AGGREGATE: 87.97% | Equivalent GPA: 4.0/4.0 | Department Rank: 1/51

HONORS AND AWARDS

2010 Best Scientific Paper Award in Bioinformatics and Biomedical Applications Track
at 20th International Conference on Pattern Recognition (ICPR 2010)
2009 Winner of the third Data Mining Practice Prize for the best deployed data mining system
in the industry at KDD 2009
2007 Received the Dean's Fellowship award for 2006-2007 for excellence in research
2007 Member of the Honor Society of Phi Kappa Phi 2007
2001 Best outgoing student in the department for the year 2000-2001
1999 Recipient of the National Science Fellowship Award (Engineering Stream) for the
year 1999 funded by the Department of Science and Technology, Government of India
1995 Recipient of the National Talent Search Examination (NTSE) scholarship

WORK EXPERIENCE

JULY 2007
Current

Research Scientist at SIEMENS HEALTHCARE, Malvern, PA, USA
Image and Knowledge Management, CAD and Knowledge Solutions Group
Designed machine learning algorithms for several commercially deployed computer aided diagnosis products that automatically identify early stage cancer of the lung, colon, and breast based on X-ray, CT, and MRI images. Involved in MRMC study design and analysis for the clinical trials. Mentored several interns.

Jun-July 2006	Summer Intern at SIEMENS MEDICAL SOLUTIONS, Malvern, PA, USA *Computer Aided Diagnosis and Therapy Group* Mentors: Dr. Harald STECK and Dr. Balaji KRISHNAPURAM Worked on personalized medicine and machine learning approaches to survival analysis.
Aug 2001-2006	Research Assistant at UNIVERSITY OF MARYLAND, CollegePark, USA *Perceptual Interfaces and Realities Labaratory* Mentors: Dr. Ramani DURAISWAMI and Dr. B. YEGNANARAYANA Scalable machine learning algorithms. Audio signal processing. Spatial audio.
Feb-Aug 2003	Intern at INTEL CORPORATION, Santa Clara, CA, USA *Future Platforms Lab, Intel Labs* Mentors: Dr.Igor KOZINTSEV and Dr.Rainer LIENHART Position calibration of a network of microphones/speakers on distributed computing platforms.
Apr-May 2000 Nov-Dec 1999	Undergraduate Intern at INDIAN INSTITUTE OF SCIENCE,Bangalore, India *Speech and Audio laboratory* | Mentor: Dr.T. V. SREENIVAS Implemented a real-time 3D spatial audio system using Head Related Transfer Functions (HRTFs). Worked on modeling and interpolation of HRTFs.
May-Jun 1999	Summer Intern at CENTRE FOR ARTIFICIAL INTELLIGENCE AND ROBOTICS Bangalore, India | Mentor: Dr. Ambalal V. PATEL Implemented PI and PD controller using Fuzzy Logic.

JOURNAL PUBLICATIONS

7. **Empirical Bayesian thresholding for sparse signals using mixture loss functions**
   Vikas C. Raykar and Linda H. Zhao
   To appear in Statistica Sinica.

6. **Learning From Crowds**
   Vikas C. Raykar, Shipeng Yu, Linda H. Zhao, Gerardo H. Valadez, Charles Florin, Luca Bogoni, and Linda Moy
   Journal of Machine Learning Research, Vol. 11, pp. 1297–1322, April 2010.

5. **Fast Computation of Kernel Estimators**
   Vikas C. Raykar, Ramani Duraiswami, and Linda H. Zhao
   Journal of Computational and Graphical Statistics, Vol. 19, No. 1, pp. 205–220, March 2010.

4. **A fast algorithm for learning a ranking function from large scale data sets**
   Vikas C. Raykar, Ramani Duraiswami, and Balaji Krishnapuram
   IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 30, No. 7, pp. 1158–1170, July 2008.

3. **Extracting the frequencies of the pinna spectral notches in measured head related impulse responses**
   Vikas C. Raykar, Ramani Duraiswami, and B. Yegnanarayana
   The Journal of the Acoustical Society of America, Vol. 118, No. 1, pp. 364–374, July 2005.

2. **Position Calibration of Microphones and Loudspeakers in Distributed Computing Platforms**
   Vikas C. Raykar, Igor Kozintsev, and Rainer Lienhart
   IEEE Transactions on Speech and Audio Processing, Vol. 13, No. 1, pp. 70–83, Jan. 2005.

1. | **Speaker Localization using excitation source information in speech**
Vikas C. Raykar, B.Yegnanarayana, S. R. Mahadeva Prasanna, and Ramani Duraiswami
IEEE Transactions on Speech and Audio Processing, Vol. 13, No. 5, Part 2, pp. 751–761, Sep. 2005.

Peer Reviewed Conference Publications

Highly selective machine learning conference papers (NIPS, AISTATS, ICML, KDD) are marked as [†].

20. | **Designing efficient cascaded classifiers: Tradeoff between accuracy and cost** [†]
Vikas C. Raykar, Balaji Krishnapuram, and Shipeng Yu
KDD'10 | Proceedings of the 16th ACM SIGKDD international conference on Knowledge discovery and data mining (KDD), pp. 853–860, Washington DC, July 2010. [acceptance rate 17%] [oral presentation]

19. | **A Multiple Instance Learning Approach toward Optimal Classification of Pathology Slides**
Murat Dundar, Sunil Badve, Vikas C. Raykar, Rohit Jain, Olcay Sertel, and Metin Gurcan
ICPR'10 | Proceedings of 20th International Conference on Pattern Recognition, Turkey, August 2010. [acceptance rate 18%]
[Best Scientific Paper Award in Bioinformatics and Biomedical Applications Track]

18. | **Nonparametric prior for adaptive sparsity** [†]
Vikas C. Raykar and Linda H. Zhao
AISTATS'10 | In Proceedings of the Thirteenth International Conference on Artificial Intelligence and Statistics (AISTATS) 2010, JMLR: W&CP 9, pp. 629–636, Italy, May 2010.

17. | **Mining Medical Images**
R. Bharat Rao, Glenn Fung, Balaji Krishnapuram, Jinbo Bi, Murat Dundar, Vikas C. Raykar, Shipeng Yu, Sriram Krishnan, Xiang Zhou, Arun Krishnan, Marcos Salganicoff, Luca Bogoni, Matthias Wolf, Anna Jerebko, and Jonathan Stoeckel.
KDD'09 | Proceedings of the Third Workshop on Data Mining Case Studies and Practice Prize, Fifteenth Annual SIGKDD International Conference on Knowledge Discovery and Data Mining (KDD), Paris, June 2009.
[First place prize winner]

16. | **Supervised Learning from Multiple Experts: Whom to trust when everyone lies a bit** [†]
Vikas C. Raykar, Shipeng Yu, Linda Zhao, Anna Jerebko, Charles Florin, Gerardo Valadez, Luca Bogoni, and Linda Moy
ICML'09 | Proceedings of the 26th International Conference on Machine Learning (ICML), pp. 889–896, Montreal, June 2009.

15. | **Bayesian Multiple Instance Learning: Automatic Feature Selection and Inductive Transfer** [†]
Vikas C. Raykar, Balaji Krishnapuram, Jinbo Bi, Murat Dundar, and R. Bharat Rao
ICML'08 | Proceedings of the 25th International Conference on Machine Learning (ICML), pp. 808–815, Helsinki, July 2008.

14. | **Polyhedral Classifier for Target Detection A Case Study: Colorectal Cancer** [†]
Murat Dundar, Matthias Wolf, Sarang Lakare, Marcos Salganicoff, and Vikas C. Raykar
ICML'08 | Proceedings of the 25th International Conference on Machine Learning (ICML), pp. 288–295, Helsinki, July 2008.

13. | **Automatic online tuning for fast Gaussian summation** [†]
Vlad I. Morariu, Balaji V. Srinivasan, Vikas C. Raykar, Ramani Duraiswami, and Larry Davis
NIPS'08 | Advances in Neural Information Processing Systems (NIPS), vol. 21, pp. 1113–1120, 2009.

12. | **Multiple instance learning improves CAD detection of masses in digital mammography**
Balaji Krishnapuram, Jonathan Stoeckel, Vikas C. Raykar, R. Bharat Rao, Philippe Bamberger, Eli Ratner, Nicolas Merlet, Inna stainvas, Menahem Abramov, and Alexandra Manevitch
IWDM'08 | Proceedings of the 9th international workshop on Digital Mammography (IWDM), pp. 350–357, Tucson, AZ, July 2008. [oral presentation]

11. On Ranking in Survival Analysis: Bounds on the Concordance Index [†]
NIPS'07 | Vikas C. Raykar, Harald Steck, Balaji Krishnapuram, Cary Dehing-Oberije, Philippe Lambin
Advances in Neural Information Processing Systems (NIPS), vol. 20, pp. 1209 -1216 , 2008.

10. A fast algorithm for learning large scale preference relations [†]
AISTATS'07 | Vikas C. Raykar, Ramani Duraiswami, and Balaji Krishnapuram
Proceedings of the 11th International Conference on Artificial Intelligence and Statistics (AISTATS), pp. 385-392, Peurto Rico, March 2007. [oral presentation]

9. Efficient Kriging via Fast Matrix-Vector Products
AERO'08 | Nargess Memarsadeghi, Vikas C. Raykar, Ramani Duraiswami, and David M. Mount
IEEE Aerospace Conference, Big Sky, Montana, March 2008.

8. Fast optimal bandwidth selection for kernel density estimation
SDM'06 | Vikas C. Raykar and Ramani Duraiswami
Proceedings of the sixth SIAM International Conference on Data Mining, pp. 524–528, Bethesda, April 2006.

7. The manifolds of spatial hearing
ICASSP'05 | Ramani Duraiswami and Vikas C. Raykar
Proceedings of International Conference on Acoustics, Speech and Signal Processing (ICASSP), vol. III, pp. 285–288, Philadelphia, March 2005.

6. Approximate expressions for the mean and the covariance of the maximum likelihood estimator for acoustic source localization
ICASSP'05 | Vikas C. Raykar and Ramani Duraiswami
Proceedings of International Conference on Acoustics, Speech and Signal Processing (ICASSP), vol. III, pp. 73–76, Philadelphia, March 2005.

5. Automatic Position Calibration of Multiple Microphones
ICASSP'04 | Vikas C. Raykar and Ramani Duraiswami
Proceedings of International Conference on Acoustics, Speech and Signal Processing (ICASSP), vol. IV, pp. 69–72, Montreal, Canada, May 2004.

4. Position Calibration of Audio sensors and actuators in a distributed computing platform
ACMMM'03 | Vikas C. Raykar, Igor Kozintsev and Rainer Lienhart
ACM Multimedia 2003, pp. 572-581, Berkeley, November 2003.

3. Tracking a moving speaker using excitation source information
ES'03 | Vikas C. Raykar, Ramani Duraiswami, B.Yegnanarayana, and S. R. Mahadeva Prasanna
Proceedings of the 8th Eur. Conf. Speech Communication Technology, pp. 69–72, Geneva, September 2003.

2. Extracting significant features from the HRTF
ICAD'03 | Vikas C. Raykar, B.Yegnanarayana, R. Duraiswami, and L. Davis
Proceedings of the 9th International Conference on Auditory Display (ICAD 2003), pp. 115–118, Boston, July 2003.

1. Virtual audio system customization using visual matching of ear parameters
ICPR'02 | D. Zotkin, R. Duraiswami, L. Davis, A. Mohan, and Vikas C. Raykar,
Proceedings of the 16th Int. Conference on Pattern Recognition, Vol. 3, pp. 1003–1006, Quebec City, August 2002.

PEER REVIEWED ABSTRACTS / WORKSHOP PAPERS / INVITED TALKS

14. Active Learning for Model Selection
Vikas C. Raykar and Subhadeep Mukhopadhyay
Proceedings of the 5th Annual Machine Learning Symposium, New York, pp. 91–92 October 2010.

13. CT colonography: Retrospective evaluation of the performance of computer-aided detection of colonic polyps in tagged and untagged preparation
T. Mang, L. Bogoni, M. Salganicoff, M. Wolf, V. Raykar, M. Macari, and A. Graser
In the annual meeting of the European Congress of Radiology (ECR), March 2010.

12. Effect of a concurrent virtual dissection with CAD for CTC interpretation: A multi-reader study evaluating accuracy and interpretation times
A.A. Ahmad, M. Macari, K.C. Cho, J.A. Bonavita, E. Robinson, L. Bogoni, M. Salganicoff, M. Wolf, and V. Raykar
In the annual meeting of the European Congress of Radiology (ECR), March 2010.

11. CT Kolonographie: Multizentrische Evaluation der Leistungsfähigkeit Computer-assistierter Detektion (CAD) kolorektaler Polypen bei Patientenvorbereitung mit und ohne Fecal Tagging
T. Mang, L. Bogoni, M. Salganicoff, M. Wolf, V. Raykar, M. Macari, P. Pickhardt, H. Ringl, and A. Graser
Österreichisch-Bayerischer Röntgenkongress 2010

10. Assessment of Computer-aided Nodule Detection Algorithm on Pathology Proved CT Data Sets
Sangmin Park, Tae Jung Kim, Vikas C. Raykar, Vikram Anand, Maneesh Dewan, and Anna Jerebko
In Radiological Society of North America scientific assembly and annual meeting program (RSNA 2008), November 2008. [oral presentation]

9. Sparse non-parametric Bayesian shrinkage for high dimensional problems
Vikas C. Raykar and Linda H. Zhao
Invited talk at IMS-China International Conference on Statistics and Probability 2009, July 3-6, 2009, Weihai, China.

8. Non-parametric prior for adaptive sparsity
Vikas C. Raykar and Linda H. Zhao
Poster at the 4th Annual Machine Learning Symposium, New York, November 6 2009.

7. Fast large scale Gaussian process regression using approximate matrix-vector products
Vikas C. Raykar and Ramani Duraiswami
Presented at the Learning workshop 2007, San Juan, Peurto Rico, March 2007

6. On the manifolds of spatial hearing
Vikas C. Raykar and Ramani Duraiswami
Presented at the NIPS 2006 workshop on Novel Applications of Dimensionality Reduction.

5. The improved fast Gauss Transform with applications to machine learning
Vikas C. Raykar and Ramani Duraiswami
Presented at the NIPS 2005 workshop on Large scale kernel machines.

4. Extracting the frequencies of the pinna spectral notches in measured head related impulse responses
Vikas C. Raykar, Ramani Duraiswami, and B. Yegnanarayana
Presented at the 148th meeting of Acoustical Society of America, San Diego, California, November 2004.

3. A study of pinna anthropometry and the spectral notch frequencies
Vikas C. Raykar, Ramani Duraiswami, and B. Yegnanarayana
Presented at the 148th meeting of Acoustical Society of America, San Diego, California, November 2004.

2. Self Localization of acoustic sensors and actuators on distributed platforms
Vikas C. Raykar, Igor Kozintsev and Rainer Lienhart
ICCV 2003 International Workshop on Multimedia Technologies in E-Learning and Collaboration, Nice, France, October 2003.

1. Head Related Impulse Response Interpolation for Dynamic Spatialization
T.V.Sreenivas, Vikas C. Raykar and Ramesh Raman
Presented at the Texas Instruments DSPS fest-2k, November 2000, Banglore, India.

Book Chapters

4. | Lung Nodule Detection
   Luca Bogoni, Jinbo Bi, Charles Florin, Anna K. Jerebko, Arun Krishnan, Sangmin Park, Vikas C. Raykar, and Marcos Salganicoff
   In ImageCLEF: Experimental Evaluation in Visual Information Retrieval, 2010, Volume 32, Part 3, pp 415-434, Springer Berlin Heidelberg.

3. | The Improved Fast Gauss Transform with applications to machine learning
   Vikas C. Raykar and Ramani Duraiswami
   Book chapter in Large-Scale Kernel Machines, L. Bottou, O. Chapelle, D. DeCoste and J. Weston (Eds.), pp. 175–201, MIT Press 2007.

2. | Multimodal tracking for smart videoconferencing and video surveillance
   Dmitry Zotkin, Vikas C. Raykar, Ramani Duraiswami and Larry S. Davis
   In Multimodal Surveillance: Sensors, Algorithms, and Systems, ed. by Z. Zhu and T. S. Huang, Artech House Publishers, Norwood, MA, 2007, pp. 141-175.

1. | Providing Common Time and Space in Distributed AV-Sensor Networks by Self-Calibration
   R. Lienhart, I. Kozintsev, D. Budnikov, I. Chikalov, and Vikas C. Raykar
   In Intelligent Multimedia Processing with Soft Computing Series: Studies in Fuzziness and Soft Computing, Vol. 168 Y. Tan, K. H. Yap, and L. Wang (Eds.) 2005.

Technical Reports

4. | Fast weighted summation of erfc functions
   Vikas C. Raykar, R. Duraiswami, and B. Krishnapuram
   CS-TR-4848, Department of computer science, University of Maryland, CollegePark.

3. | Very fast optimal bandwidth selection for univariate kernel density estimation
   Vikas C. Raykar and R. Duraiswami
   CS-TR-4774, Department of computer science, University of Maryland, CollegePark.

2. | Fast computation of sums of Gaussians in high dimensions
   Vikas C. Raykar, C. Yang, R. Duraiswami, and N. Gumerov
   CS-TR-4767, Department of computer science, University of Maryland, Collegepark.

1. | Extracting frequencies of the pinna spectral notches in measured head related impulse responses
   Vikas C. Raykar, C. Yang, R. Duraiswami, and N. Gumerov
   CS-TR-4609, Department of Computer Science. University of Maryland CollegePark (also published as UMIACS-TR-2004-51).

Patents and Intellectual Property Disclosures

9. | Systems and methods for providing a second opinion reading paradigm for computer aided diagnosis United States Patent Application 201020002
   Vikas C. Raykar

8. | Systems and methods for simultaneous parallel dump and serial waterfall model for allocating new data United States Patent Application 201020001
   Vikas C. Raykar, Matthias Wolf, and Marcos Salganicoff

7. | Systems and methods for metric learning based polyp prone/supine view matching to improve CAD performance United States Patent Application 201020675
   Meizhu Liu, Le Lu, Vikas C. Raykar, and Marcos Salganicoff

6. | Soft-gated classifier architectures for computer aided diagnosis
   United States Patent Application 200909273
   Vikas C. Raykar, Shipeng Yu, Jinbo Bi, and Marcos Salganicoff

5. | Method to establish a gold standard with contradictory information from multiple experts
   United States Patent Application 200900033
   Vikas C. Raykar, Shipeng Yu, Charles Florin, and Anna Jerebko

4. | A probabilistic framework for efficient design of cascade of linear classifiers with applications to personalized medicine and computer aided diagnosis United States Patent Application 200810572
   Vikas C. Raykar, Balaji Krishnapuram, Shipeng Yu, and R. Bharat Rao

3. | Multiple instance classification algorithms for computer aided diagnosis
   United States Patent Application 200720952
   Vikas C. Raykar, Balaji Krishnapuram, Murat Dundar, and R. Bharat Rao

2. | Method for three-dimensional position calibration of audio sensors and actuators on a distributed computing platform US Patent number 6,941,246, 2005
   Vikas C. Raykar, Rainer W. Lienhart, and Igor V. Kozintsev

1. | Three-dimensional position calibration of audio sensors and actuators on a distributed computing platform US Patent number 7,035,757, 2005
   Vikas C. Raykar, Igor V. Kozintsev, and Rainer W. Lienhart

Open Source Software

The various fast algorithms that I developed during my doctoral dissertation are released under the GNU Lesser General Public License (LGPL) and have been widely downloaded.

1. The improved fast Gauss Transform
2. FIGTree: Fast Improved Gauss Transform with Tree Data Structure
3. Fast optimal bandwidth selection for kernel density estimation
4. Fast summation of erfc functions and ranking

Computing Skills

Expertise in MATLAB, R, C, and C++.

Experience with various MRMC analysis software.

Interns supervised

2010   Subhadeep Mukhopadhyay
        Department Statistics, Texas A&M University
        Learning loop for cloud based computer-aided diagnosis

2010   Meizhu Liu (co-supervised with Le Lu)
        Department of Computer and Information Science and Engineering, University of Florida
        Colon polyp prone-supine matching using metric learning methods

2008   Oksana Yakhnenko (co-supervised with Balaji Krishnapuram)
        Computer Science Department, Iowa State University
        Predictive models for breast cancer diagnosis

Service and Professional Activities

Member American Statistical Association, ACM Special Interest Group on Knowledge Discovery and Data Mining, American Association of Physicists in Medicine (AAPM) Computer Aided Detection in Diagnostic Imaging (CAD) Subcommittee.

Journal Reviewer Journal of Machine Learning Research, IEEE Transactions on Pattern and Machine Intelligence, Neurocomputing, Data Mining and Knowledge Discovery, IEEE Transactions on Speech and Audio Processing, IEEE Transactions on Signal Processing, Cytometry Part A.

Conference Reviewer AISTATS 2011, Ad-hoc reviewer for ICML, AISTATS, KDD, and NIPS conferences, ICASSP 2005.

Program Committee NIPS 2010 workshop on Predictive Models in Personalized Medicine.