Namrata Vaswani

Contact Information

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Education

University of Maryland, College Park
Ph.D, Electrical and Computer Engineering (August 2004)
Major: Communications and Signal Processing, **Minor:** Controls
Dissertation: *Change Detection in Stochastic Shape Dynamical Models with Applications in Activity Modeling and Abnormal Activity Detection*
Advisor: Prof. Rama Chellappa

Indian Institute of Technology (IIT), Delhi
B.Tech., Electrical Engineering (May 1999)
B.Tech Thesis: *Recognition of Dynamic Hand Gestures for Robot Control*

Areas of Interest

- Image and Video Processing, Machine Learning, Computer Vision
- Medical Image Analysis, Neural and Acoustic Signal Processing
- Shape Analysis, Dynamical models and Filtering
- Particle Filtering Theory and Applications
- Change Detection and Estimation
- **Other Interests:** Information Theory, Video Compression

Professional Experience

- **Assistant Professor, Dept. of Electrical and Computer Engineering, Iowa State University, Aug'05 - Present**
- **Research Scientist, School of Electrical and Computer Engineering, Georgia Institute of Technology, Jan'05 - Aug'05**
  - Particle filtering for geometric active contours (continuous closed curves)
  - Fusing acoustic and video information for robust tracking
  - Joint tracking and segmentation using optical flow
- **Postdoctoral Fellow, School of Electrical and Computer Engineering, Georgia Institute of Technology, Aug'04 - Dec'04**
  - Particle filtering for geometric active contours (continuous closed curves)
- **Graduate Research Assistant, Center for Automation Research, University of Maryland at College Park, Jan'00 - Aug'04**
  - Particle filtering for tracking adaptive neural responses in the auditory cortex
  - Change detection using particle filters with unknown change parameters
  - Dynamical models for landmark shape and applications to activity recognition
  - Principal Component Null Space Analysis for image classification
  - Infra-red image compression

- **Research Intern, HRL(formerly Hughes Research Labs), Malibu,CA, June-Oct'01**
  - Vision based object detection for collision warning
  - Overcomplete blind source separation using Independent Component Analysis

- **Intern, Synergy Systems and Solutions, Delhi, India, May-Aug'99**
  - Research Review on Algorithms for Developing a Pipeline Leak Detection Software

- **Undergraduate Thesis, Dept. of Electrical Engineering, IIT-Delhi, Aug'98 - May'99**
  - Recognition of dynamic hand gestures for robot control

- **Intern, Philips Semiconductors, Bangalore, India, May-July'98**
  - Design and Synthesis of a Peripheral Interface Bus Controller

- **Summer Undergraduate Research Award, CARE, IIT-Delhi, May - July'97**
  - Awarded a research grant and stipend for the project "Time and frequency domain characterization of Surface Acoustic Wave devices and cancelation of Triple Transit Interference"

Computer Skills

- **Operating Systems:** Unix, Linux, Windows
- **Languages/Software:** C, C++, Visual C++, MATLAB, LaTeX, Open Inventor

Honors/Awards

- Invited to participate in the American Institute of Mathematics (AIM) workshop on Statistical Inferences on Shape Manifolds, May 6-9 2005
- ICASSP 2004 paper on "*Bound on Errors in Particle Filtering with Incorrect Model Assumptions and its Implication for Change Detection*", chosen among top 15% papers, recommended for submission to IEEE Signal Processing Society journals
- Nominated for best B.Tech project in Electrical Engineering at IIT-Delhi, 1999
- Summer Undergraduate Research Award (SURA) at IIT-Delhi, 1997
- Gold medal in Delhi Regional Mathematics Olympiad, 1995

Invited Talks

- Dept. of Mathematics and Statistics, Queen's University, Canada, February 7, 2005
- Dept. of Electrical and Computer Engineering, NC State University, Raleigh, NC, March 11, 2005
- Seminar Series in Vision, University of Maryland, College Park, March 18, 2005
- Siemens Medical Systems, Malvern, PA, March 21, 2005
- GE Global Research, Niskayuna, NY, April 29, 2005
- Dept. of Electrical and Computer Engineering, Iowa State University, Ames, IA, May 2, 2005
- ARO-MURI Workshop on Adaptive Sensing and Waveform Design, Georgia Tech, Atlanta, GA, August 2, 2005

Professional Activities

- Reviewer for IEEE Trans. on Image Processing, IEEE Trans. on PAMI, Pattern Recognition Letters, Journal of Statistical Planning and Inference
- Reviewer for IEEE Conf. on Decision and Control (CDC), American Control Conference (ACC)
- Member of IEEE and IEEE Signal Processing Society

Course Work

Stochastic Processes, Estimation and Detection Theory, Information Theory,
Image Processing, Image Understanding, Statistical Signal Processing, Advanced Digital Signal Processing,
Linear System Theory, Optimal Control, Seminar classes on Optimization, Particle Filtering,
Real Analysis-I & II, Mathematical Statistics-II,
Digital Communications, Seminar class on Signal Processing for Communications

Publications *(Downloadable from http://users.ece.gatech.edu/∼namrata/publications.html)*

Journal/Book Chapters

1. Y. Rathi, **N. Vaswani**, A. Tannenbaum, A. Yezzi "*Tracking Deforming Objects Using Particle Filtering for Geometric Active Contours*", submitted.
2. **N. Vaswani**, "*Particle Filtering Under System Model Error*", in preparation for IEEE Trans. on Signal Processing, 2005.
3. **N. Vaswani**, "*Slow and Drastic Change Detection in General HMMs Using Particle Filters with Unknown Change Parameters*", to be submitted to IEEE Trans. on Signal Processing, 2005.
4. **N. Vaswani**, R. Chellappa, "*Principal Component Null Space Analysis for Image and Video Classification*", Accepted for IEEE Trans. on Image Processing, 2005.
5. **N. Vaswani**, A. RoyChowdhury, R. Chellappa, "*"Shape Activities": Stochastic Models for Moving/ Deforming Shapes with Application to Abnormal Activity Detection*", To Appear in IEEE Trans. on Image Processing, September 2005.
6. A. Ramamoorthy, **N. Vaswani**, S. Chaudhury, S. Bannerjee, "*Recognition of Dynamic Hand Gestures*", Pattern Recognition, Vol. 36, No. 9, pp. 2069-2081, Sept 2003.
7. **N. Vaswani**, A. K. Agrawal, Q. Zheng, R. Chellappa, "*Moving Object Detection and Compression in IR Sequences*", book chapter in Computer Vision beyond the Visible Spectrum, Eds B. Bhanu and I. Pavlidis, Springer, 2003.

Conferences

1. **N. Vaswani**, R. Chellappa "*NonStationary Shape Activities*", Accepted for IEEE Conference on Decision and Control (CDC), 2005.
2. Y. Rathi, **N. Vaswani**, A. Tannenbaum, A. Yezzi "*Particle Filtering for Geometric Active Contours and Application to Tracking Deforming Objects*", accepted for IEEE Conf. on Computer Vision and Pattern Recognition (CVPR), 2005.
3. **N. Vaswani**, "*The Modified CUSUM Algorithm for Slow and Drastic Change Detection in General HMMs with Unknown Change Parameters*", accepted for IEEE Intl. Conf. on Acoustics, Speech and Signal Processing (ICASSP), 2005.
4. **N. Vaswani**, "*Bound on Errors in Particle Filtering with Incorrect Model Assumptions and its Implication for Change Detection*", IEEE Intl. Conf. on Acoustics, Speech & Signal Processing (ICASSP), 2004.
5. **N. Vaswani**, "*Change Detection in Partially Observed Nonlinear Dynamic Systems With Unknown Change Parameters*", American Control Conference (ACC), 2004.
6. **N. Vaswani**, R. Chellappa, "*Classification Probability Analysis of Principal Component Null Space Analysis*", Intl. Conf. on Pattern Recognition (ICPR), 2004.
7. **N. Vaswani**, A. RoyChowdhury, R. Chellappa, "*Activity Recognition Using the Dynamics of the Configuration of Interacting Objects*", IEEE Conf. on Computer Vision and Pattern Recognition (CVPR), 2003.
8. **N. Vaswani**, A. RoyChowdhury, R. Chellappa, "*Statistical Shape Theory for Activity Modeling*", IEEE Intl. Conf. on Acoustics, Speech and Signal Processing (ICASSP), 2003.
9. **N. Vaswani**, R. Chellappa, "*A Particle Filtering Approach to Abnormality Detection in Nonlinear Systems and its Application to Abnormal Activity Detection*", 3rd Intl. Workshop on Statistical and Computational Theories of Vision, 2003.

10. R. Chellappa, **N. Vaswani**, A. RoyChowdhury, "*Activity Modeling and Recognition Using Shape Theory*", Behavior Representation in Modeling and Simulation (BRIMS), 2003.
11. **N. Vaswani**, "*A Linear Classifier for Gaussian Class Conditional Distributions with Unequal Covariance Matrices*", Intl. Conf. on Pattern Recognition (ICPR), 2002.
12. **N. Vaswani**, R. Chellappa, "*Best View Selection and Compression of Moving Objects in IR Sequences*", IEEE Intl. Conf. on Acoustics, Speech and Signal Processing (ICASSP), 2001.

Research Summary

- **Change Detection Using Particle Filters with Unknown Change Parameters**
  We study the problem of change detection in general HMMs (state space models) using particle filters when the changed system parameters are unknown and the change can be slow or drastic. Drastic changes can be detected easily using the increase in tracking error (TE) or negative logarithm of the observation likelihood (OL). For slow changes which get missed by OL or TE, we propose a statistic called ELL and show its connection to Kerridge Inaccuracy. We show stability of the errors in approximating ELL, analyze their behavior with increasing rate of change, and also show complementary behavior of ELL and OL for slow and drastic changes. Applications to abnormal activity detection, detecting changes in bearings-only tracking and to tracking neural responses in the auditory cortex are presented.
- **A Particle Filter for Tracking Adaptive Neural Responses in Auditory Cortex**
  Ongoing work with Madhvi Jain, Mounya Elhilai, Prof. Shihab Shamma, Dr. Jonathan Fritz
  We propose a particle filtering algorithm to detect and track changes in spectrotemporal receptive fields (STRFs) in the auditory cortex, induced by performance of various acoustic tasks. It is demonstrated experimentally that this algorithm is more robust than previously used reverse-correlation methods. Using the ELL and tracking error statistics, the particle filter is able to detect changes in the system that are missed using previous methods. Simple heuristics have been proposed to track the changes.
- **Dynamical Models for Landmark Shape and Applications to Activity Recognition**
  Joint work with Prof. Amit RoyChowdhury, Prof. Rama Chellappa
  The aim is to model "activity" performed by a group of moving and interacting objects (which can be people or cars or different rigid components of the human body). We treat the objects as point objects (referred to as "landmarks") and model their changing configuration as a moving and deforming "shape" using ideas from Kendall's shape theory for landmarks. A continuous state HMM which takes the objects' configuration as the observation and the shape+motion as the hidden state, is defined to represent an activity. Particle filters are used to track the HMM. Abnormal activity is defined as a change in the HMM, which can be slow or drastic and whose parameters are unknown. We show application to detecting abnormal activities, tracking human actions and detecting motion disorders and for activity segmentation.
- **Particle Filtering for Geometric Active Contours (Continuous Curves)**
  Ongoing work with Yogesh Rathi, Prof. Allen Tannenbaum, Prof. Anthony Yezzi
  Geometric active contours can be represented implicitly as the zero level set of the graph of a higher dimensional function. The representation is able to deal with changes in topology of the contour and has been used very successfully for segmentation and registration problems. But tracking involves estimating the global motion of the object and its local deformations as a function of time. Tracking algorithms using particle filtering have been proposed in past work for parametric representations of shape. But these are dependent on the chosen parametrization and cannot handle changes in curve topology. We have proposed a particle filtering algorithm for implicitly represented geometric active contours and shown its application to tracking moving and deforming objects.
- **Principal Component Null Space Analysis (PCNSA) for Image Classification**
  Joint work with Prof. Rama Chellappa
  PCNSA is a new classification algorithm, which we propose for problems like object recognition where different classes have unequal and non-white noise covariance matrices. We derive upper bounds on classification error probability of PCNSA and use these expressions to show superior classification performance of PCNSA when compared with that of Subspace Linear Discriminant Analysis (SLDA) under certain assumptions. We provide an experimental comparison of PCNSA with SLDA and PCA

and also with Support Vector Machines, kernel PCA and kernel discriminant analysis, for object recognition, face recognition and video retrieval.

References

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