Debejyo Chakraborty

Ph.D., Electrical Engineering
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Profile

Deep understanding and expertise in algorithms, data acquisition, data modeling and analysis. Five years of research experience in digital signal processing, algorithm design and analysis for interdisciplinary research. Research statistical data mining, data modeling, parametric and non-parametric estimation and machine learning algorithms. Algorithms designed in MATLAB and C/C++. Large volumes of data often dictated multi-core implementation (using MPI) of the algorithms for time-efficient parallel computing. Research findings are documented in ten published manuscripts with more in preparation. An active team member/leader with great communication, public presentations and interpersonal skills.

Areas of Interest

- Multi-core algorithm design and analysis
- Adaptive data modeling and analysis
- Machine learning / transfer learning
- Data mining
- Non-parametric Bayesian estimation
- Detection and estimation theory
- Pattern recognition and classification
- Sensor/data fusion & optimization
- Digital signal processing & time-frequency analysis
- Stochastic filtering (Kalman filtering, Particle filtering, Bayesian filtering)
- Compressed sensing

Professional Preparation

July 2010 **Ph.D.**, *Electrical Engineering (Signal Processing)*, GPA 3.70/4, Dissertation: "Time-Frequency Based Adaptive Learning for Structural Health Management".
School of Electrical, Computer & Energy Engineering (ECEE), Arizona State University, Tempe, AZ.

May 2010 **M.S.**, *Electrical Engineering (Signal Processing)*, GPA 3.70/4, Report: "Damage Classification for Structural Health Monitoring Using Time-frequency Techniques".
School of Electrical, Computer & Energy Engineering (ECEE), Arizona State University, Tempe, AZ.

2005 **B.E.**, *Instrumentation Technology*, GPA 74/100.
Dept. of Instrumentation Technology, JSS Academy of Technical Education, Visveswaraiah Technological University, Karnataka, India

Experience

Academic/research

2010–current **Postdoctoral Scholar**, *Arizona State University*, Tempe, AZ.
Research in signal processing and statistical modeling in School of Electrical, Computer & Energy Engineering.

2006–2010 **Research Assistant**, *Arizona State University*, Tempe, AZ.
Signal Processing & Adaptive Sensing Laboratory (http://spaslab.asu.edu), in adaptive estimation and classification.

Fall 2005 **Radar testing and calibration**, *San Diego State University*, San Diego, CA.
Testing of radar and design of process automation using Labview.

Spring 2005 **Design Engineer intern**, *Hindustan Aeronautics Limited*, Bangalore, India.
Intern for design of Engine Test Bed Spectral Analyzer.

Teaching

Spring 2006 **Grading for Signals and Systems**, *Arizona State University*, Tempe, AZ.

Fall 2005 **Tutoring services**, *San Diego State University*, San Diego, CA.
Topics included Electrical Networks, Logic Design, Signals and Systems and Object Oriented Programming using C++

Fall 2005 **Grading for Circuit Design and related Laboratory work**, *San Diego State University*, San Diego, CA.

Other

2006–current **Website developer, graphic designer & photographer**, *AIMS Center, SenSIP Center and SPAS Laboratory in ASU*.

Research

Adaptive Learning Using Time-frequency Features for Detecting Damage on Aircrafts

Abstract Advanced signal processing methods were developed to complement the existing preliminary signal processing technologies used in damage detection and prognosis in aerospace structures. This research introduced the use of matching pursuit decomposition as feature extraction, noise reduction and statistical classification technique. Hidden Markov models were used to quantify damage from the sequential feature information. Adaptive learning method was introduced as a closed loop dynamic system to model progressive damage and perform robust classification. This method also incorporated Occam's Razor principle and used active data selection for efficient performance. Transfer learning method was implemented to demonstrate information transfer among related experiments that can reduce computational and resource overheads.

Technology, Achievements & Contributions

- ✈ *Filter design:* for preliminary signal preprocessing including noise removal, followed by downsampling, normalizing/scaling.
- ✈ *Feature extraction using matching pursuit decomposition:* time series information is encoded into joint time-frequency based multi-dimensional parameter space to perform signal compression, in-band noise reduction and transforms. It was also used for a time-frequency based signal classification. I introduced a selective atom signal reconstruction to improve classification performance for signals with overlapping spectrum.
- ✈ *Hidden Markov modeling:* stochastic method to model sequence information in feature/observation. I used both discrete observation and continuous observation hidden Markov models and they provided robust classification.
- ✈ *Variational Bayesian inference:* Used to estimate model complexity and provides a learned ensemble over the features. I used this to estimate states in hidden Markov models.
- ✈ *Adaptive learning:* Non-parametric Bayesian estimation method. I designed a closed loop progressive estimation state-space formulation. This method is online and adaptive, and it does not require baseline training data. It incorporates the following salient features
  - *Dimensionality reduction:* high dimensional features are complex and expensive to model. I defined a time-frequency based probability density function that can reduce multi-dimensional feature to a 1-dimensional space using relative statistical similarity measure.
  - *Active learning:* Used for judicious data selection. Processing redundant data is computationally expensive and does not yield any benefits. I designed discrepancy based data selection methodology to enhance clustering performance in adaptive learning.
  - *Dirichlet process:* In this research it is used as statistical priors for the non-parametric Bayesian estimates. I have implemented this estimation in a recurring closed loop system with information sharing with previous epochs. Used Markov chain Monte Carlo for sampling.
  - *Bayesian filtering:* Used for stochastic estimation in a state-space formulation. A Physics based theoretical state model was used. I designed a data driven parametric measurement model that evolved with changing data to incorporate Bayes' filter in a closed loop system. Results show excellent estimation performance.
- ✈ *Transfer Learning:* Provides a platform for information sharing and reusing among related experiments. I designed a translated learning with appropriate target predictive function to perform classification on sensors with minimum training data. This has significant computational advantages and experiments have shown promising results.
- ✈ *MATLAB:* Interpreter based object oriented programming platform that provides programmer friendly environment for matrix and symbolic mathematics. I use this tool for algorithm prototyping.
- ✈ *C/C++ parallel programming:* Provides an efficient algorithm development and implementation platform. Often I had to handle large volumes of data. I implemented the computationally complex and intensive algorithms in a parallel framework that is capable of utilizing multiple cores and even multiple computers over a network. This method is benefits of exponentially fast computation speed and efficient resource management.
- ✈ *Mathematica:* I used this for algebraic simplification and building mathematical formulae used at various stages of my research.

Advisor Prof. Antonia Papandreou-Suppappola

Web http://murishm.engineering.asu.edu/

Sponsor Air Force Office of Scientific Research (AFOSR) MURI Grant FA95550-06-1-0309

Perimeter security using sensor motes network

Abstract This research was geared towards building a security perimeter using an array of inexpensive sensor systems. We used footstep data as the acoustic sensors. Research was conducted to study the nature of signals generated when one walks with various shoe types on various grounds. Time-frequency analysis revealed the existence of short temporal duration high frequency signals. This concept was deployed on fixed point 8-bit sensor motes over a wireless network. The data collected were used with a particle filter for target tracking.

Technology & Achievements
- ✈ *Time-frequency analysis:* A joint time-frequency method to study time varying spectrum of signals. We used it for detection.
- ✈ *Fixed point filter design:* We designed fixed point filters to implement on fixed point architecture motes.
- ✈ *Particle filter:* Used in target tracking

Advisor Prof. Antonia Papandreou-Suppappola

Web http://spaslab.asu.edu/motes/

Programming Platforms

- ✈ **MATLAB** *advanced knowledge*
- ✈ **C/C++ (GNU)** *advanced knowledge - single/multi-core algorithm implementation using message passing interface (MPI)*

Computer Skills

Computational Mathematica.

Interfacing Labview (basic applications), Code composer studio, Verilog (HDL), MPLab.

Web-based HTML, PHP, MySQL.

Operating sys. Windows, MacOS, Linux.

Other apps. MS Office, Latex, Photoshop, Autocad.

Hardware Intel 8086 microprocessor, PIC microcontroller, TMS32xxx, MICA2 motes.

Academic Awards

2006–current **Graduate Research Assistantship**, *Arizona State University*, School of Electrical, Computer & Energy Engineering.

2006–2007 **University Graduate Fellowship**, *Arizona State University*, School of Electrical, Computer & Energy Engineering.

Selected Academic Projects

Monte Carlo Simulations

- Randomness tests includes Uniformity test, Correlation test, Periodicity test, Chi-square test, Discrepancy test.
- Simulations involving Law of large numbers, Central Limit theorem.
- Approximating integration using Monte Carlo integrals.
- Use of simulated annealing to solve traveling salesman problem.

Filtering of Stochastic Processes

- Auto-regressive and moving average (ARMA) Process filtering of stochastic processes.
- Application of Kalman Filter, Extended Kalman Filter, Second Order Extended Kalman Filter and Iterated Extended Kalman Filter for estimating stochastic parameters.
- Particle Filter for tracking target in video.

Linear Algebra and Optimization

- Quadratic optimization by steepest descent and gradient descent method.
- Convex optimization using Newton's Method for unconstrained and equality constrained problems.
- Compressed sensing.

Detection and Estimation Theory

- Detecting signals in noise and message decoding in Gaussian environment.
- Bayesian sensor fusion.
- Estimating N-dimensional volume and area using Monte Carlo methods.

Time-frequency Signal Processing

- Computing linear and quadratic time-frequency representations for signals and signal and study of properties.
- Design custom dictionary for matching pursuit decomposition to parameterize data from ultrasonic measurements.

VLSI Architecture

- Design of low latency multi-core OFDM modem.

Digital Spectral Analysis

- Estimating frequency in random signals using correlogram and periodogram power spectral densities.
- Use of ARMA model for statistical signal modeling.

Real-time Digital Signal Processing

- Design of real-time graphic equalizer.
- Design of real-time video modules like histogram equalization and thresholding.
- Real-time spectral analysis.

Digital Signal Processing

- Adaptive filtering
- Design of digital sound synthesizer using IIR filters.
- Transmission of stereo sound over noisy channels.

Publications

Papers in portable document format (*pdf*) files and *Bibtex* files are available for download for academic use from http://www.debejyo.com/Publications.htm

Journal Articles

1 D. Chakraborty, N. Kovvali, A. Papandreou-Suppappola, and A. Chattopadhyay, "Adaptive Learning with Online Bayesian Inference for Structural Health Monitoring," *IEEE Transactions on SP*, to be submitted.

2 D. Chakraborty, N. Kovvali, J. Wei, A. Papandreou-Suppappola, D. Cochran, and A. Chattopadhyay, "Damage Classification Structural Health Monitoring in Bolted Structures Using Time-frequency Techniques," *Journal of Intelligent Material Systems and Structures, special issue on Structural Health Monitoring*, vol. 20, no. 11, pp. 1289–1305, July 2009.

Invited Conference Proceedings

1 D. Chakraborty, N. Kovvali, A. Papandreou-Suppappola, and A. Chattopadhyay, "Active learning data selection for adaptive online structural damage estimation," in *Proc. of SPIE, Smart Structures and Materials & Non-destructive Evaluation and Health Monitoring*, 2010.

2 L. Channels, D. Chakraborty, B. Butrym, N. Kovvali, J. Spicer, A. Papandreou-Suppappola, M. Afshari, D. Inmand and A. Chattopadhyay, "A Comparative Study of Fatigue Damage Sensing in Aluminum Alloys using Electrical Impedance and Laser Ultrasonic Methods," in *Proc. of SPIE, Smart Structures and Materials & Non-destructive Evaluation and Health Monitoring*, 2009, to appear.

3 W. Zhou, D. Chakraborty, N. Kovvali, A. Papandreou-Suppappola, D. Cochran, and A. Chattopadhyay, "Damage classification for structural health monitoring using time-frequency feature extraction and continuous hidden Markov models," in *Asilomar Conference on Signals, Systems, and Computers*, Pacific Grove, California, November 2007, pp. 848–852.

Conference Proceedings

1 D. Chakraborty, N. Kovvali, J. Zhang, A. Papandreou-Suppappola, and A. Chattopadhyay, "Adaptive learning for damage classification in structural health monitoring," in *43rd Asilomar Conference on Signals, Systems and Computers*, Pacific Grove, California, November 2009.

2 D. Chakraborty, W. Zhou, D. Simon, N. Kovvali, A. Papandreou-Suppappola, D. Cochran, and A. Chattopadhyay, "Time-frequency methods for structural health monitoring," in *SenSIP workshop*, Sedona, AZ, May 2008.

3 D. Chakraborty, S. Soni, J. Wei, N. Kovvali, A. Papandreou-Suppappola, D. Cochran, and A. Chattopadhyay, "Physics based modeling for time-frequency damage classification," in *Proc. of SPIE, Smart Structures and Materials & Non-destructive Evaluation and Health Monitoring*, vol. 6926, 2008, p. 69260M.

4 L. Channels, D. Chakraborty, D. Simon, N. Kovvali, J. Spicer, A. Papandreou-Suppappola, D. Cochran, P. Peralta, and A. Chattopadhyay, "Ultrasonic sensing and time-frequency analysis for detecting plastic deformation in an aluminum plate," in *Proc. of SPIE, Smart Structures and Materials & Non-destructive Evaluation and Health Monitoring*, vol. 6926, 2008, p. 69260P.

5 B. Manjunath and D. Chakraborty, "Perimeter security using an acoustic sensor network," in *Research in Interdisciplinary Science and Engineering Symposium - FGSA Annual Student Symposium*, Arizona State University, Tempe, Arizona, October 2007.

6 N. Kovvali, S. Das, D. Chakraborty, D. Cochran, A. Papandreou-Suppapola, and A. Chattopadhyay, "Time-frequency based classification of structural damage," in *48th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference*, Honolulu, Hawaii, April 2007, pp. 2047–2055.

Archived Technical Presentations

1 A. Chattopadhyay, A. Papandreou-Suppappola, C. Coelho, S. Soni, D. Chakraborty, W. Zhou, N. Kovvali, S. Das, P. Peralta, "Damage Diagnosis of Complex Structures Using One-Class Support Vector Machines and Hidden Markov Models," in *Integrated Systems Health Management Conference*, Cincinnati, Ohio, August 2007.

Professional Activities

Public Presentations

✈ SPIE conference, Smart Structures and Materials & Non-destructive Evaluation and Health Monitoring, March 2010.

- SPIE conference, Smart Structures and Materials & Non-destructive Evaluation and Health Monitoring, March 2009.
- SPIE conference, Smart Structures and Materials & Non-destructive Evaluation and Health Monitoring, March 2008.
- In 48th AIAA/ ASME/ ASCE/ AHS/ ASC Structures, Structural Dynamics, and Materials Conference, April 2007
- FGSA Annual Student Symposium, Arizona State University, October 2007
- Poster presentation in research reviews, Arizona State University, 2008, 2009

Reviewer

- ASILOMAR 2010
- Neural Networks Journal (2009)
- ICASSP 2007, 2008
- SenSIP Workshop 2008

Professional Organizations

- **Institute of Electrical and Electronics Engineers (IEEE)**, *http://www.ieee.org/*.
- **International Society for Structural Health Monitoring of Intelligent Infrastructure (ISHMII)**, *http://ishmii.org/*.
- **Adaptive Intelligent Materials & Systems (AIMS) Center**, *Arizona State University*, http://aims.asu.edu.
- **Sensor Signal & Information Processing (SenSIP) Center**, *Arizona State University*, http://sensip.asu.edu/.
- **The International Society for Optical Engineering (SPIE)**, *http://spie.org/*.

Social

- Volunteer: YES middle school summer program, organized by ASU
- Volunteer: sensor & signal processing module for (middle school) Girls Have I.T. Day 2010, organized by ASU
- Organizing committee: SenSIP (IEEE) workshop 2008
- Volunteer: Women in Science & Engineering (WISE) 2007 in ASU

Languages

- **English** *Native speaker proficiency*
- **Bengali** *Native speaker*
- **Hindi** *Conversational*

References

1 **Prof. Antonia Papandreou-Suppappola**, Professor,
School of Electrical, Computer & Energy Engineering, Arizona State University.
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2 **Prof. Jennie Si**, Professor,
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3 **Prof. Aditi Chattopadhyay**, Professor,
School of Mechanical, Aerospace, Chemical & Materials Engineering, Arizona State University.
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4 **Prof. Chaitali Chakrabarti**, Professor,
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5 **Dr. Narayan Kovvali**, Assistant Research Professor,
School of Electrical, Computer & Energy Engineering, Arizona State University.
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