

## Balakrishnan Narayanaswamy

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### CONTACT INFORMATION

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### RESEARCH INTERESTS

Machine Learning as applied to sensor networks and auditory/visual scene analysis: especially estimation, target tracking, pattern classification, speech separation, speaker segmentation, and speaker recognition.

### EDUCATION

**Carnegie Mellon University, Pittsburgh, Pennsylvania USA**

Ph.D. Candidate, Electrical and Computer Engineering, Aug 2005 – present  
M.S., Electrical and Computer Engineering, Aug 2003 – July 2005

**M.S.R.I.T, under VTU, Bangalore**

B. Engineering, Electronics and Communication Engineering, May 2003

### HONORS AND AWARDS

National Talent Search Examination (NTSE) scholarship, Government of India, 1997  
Selected as one among the top 1% of Physics students in India, in selection for International Physics Olympiad,  
Awarded Jawaharlal Nehru Centre for Advanced Scientific Research scholarship for 2001.

### RESEARCH EXPERIENCE

**Carnegie Mellon University – Research Project, Aug 2006 –Present**  
**Estimation in Sensor Networks and Simultaneous Localization and Mapping of mobile robots**

**Advisors: Prof. Rohit Negi, Prof. Pradeep Khosla and Prof. Raj Reddy**  
**Collaborators: Yaron Rachlin**

Developed an algorithm that is much faster than standard Belief Propagation(BP) based inference in large scale estimation problems such as sensor networks. This included work with laser range sensors and Infra-Red temperature sensors. The sequential decoding algorithm which was developed was both accurate and fast for large number of sensor measurements.

**Carnegie Mellon University – Research Project, Aug 2005 –Aug 2006**  
**Speaker localization and Speech Separation using multiple microphones**  
**Advisors: Prof. Raj Reddy and Prof. Richard Stern**

Worked on methods for speaker localization and speech separation using multiple microphones. The aim is to use knowledge about the working of the human auditory system to improve performance. See website for more details and sound examples of work so far:  
[www.cs.cmu.edu/~muralib/speakerSep](http://www.cs.cmu.edu/~muralib/speakerSep)

**Carnegie Mellon University – Probabilistic Graphical Models Course project, Fall 2005,**

**Graphical Model Approach to Iris Matching Under Local Shifts and Occlusions**

**Collaborators: R. Kerekes, J. Thornton**

Template matching of iris images for biometric recognition typically suffers from both local deformations between the template and query images. Previous work in this area has shown that recognition accuracy can be significantly improved by imposing a probabilistic model on the local deformations. In this work, we proposed a Bayesian estimate of the deformations and occlusions by using lattice-type undirected graphical models to represent interdependent regions of the iris. The resulting algorithm was in the top 2 in both ICE DARPA evaluations. We presented theory and results as well as possible extensions. This work is under preparation for publication.

**Carnegie Mellon University – Pattern Recognition Course project, Spring 2004,  
Multiframe distortion-tolerant correlation filtering for video sequences**

**Collaborators: R. Kerekes, M. Beattie**

We developed an efficient framework for combining information from multiple correlation outputs in a probabilistic way. Our framework is capable of handling scenes with an unknown number of targets at unknown positions. The main algorithm in our framework uses a probabilistic mapping of the correlation outputs and takes advantage of a position-independent target motion model in order to efficiently compute posterior target position probabilities. An important feature of the framework is the ability to incorporate any existing correlation filter design, thus facilitating the construction of a distortion-tolerant multi-frame ATR. Our simulation results show that the multi-frame algorithm significantly improves the recognition performance of a MACE-MRH filter while requiring only a marginal increase in computation. We also show that, for an equivalent amount of added computation, using larger filter banks instead of multi-frame information is unable to provide a comparable performance increase.

**Carnegie Mellon University – Masters Research Project, Aug 2003 – August 2005  
Speaker Segmentation and Speaker recognition in telephone conversations**

**Advisors: Prof. Raj Reddy and Prof. Richard Stern**

We worked on methods for segmenting speakers participating in a conversation, without any prior knowledge of the speakers' characteristics. Work was also done on methods to improve speaker recognition accuracy when only a limited amount of data was available during training and testing.

**M.S.R.I.T and Indian Institute of Science, Bangalore – Undergraduate Thesis 1, Aug – May 2002**

**Title – Test bed in Matlab for Orthogonal Frequency Division Multiplexing for Mobile Communication**

**Advisor: Prof. K.V.S Hari**

This project involves constructing a test bed in Matlab, for the various properties of a channel, such as multi-path channel, fading channel or a noisy channel. The physical layer IEEE 802.11a standard was implemented, and the method of Orthogonal Frequency Division Multiplexing (OFDM) was evaluated in noise and multi-path channels.

**Indian Institute of Science, Bangalore – JNSCAR fellowship, Aug – May 2001**

**Title – Ethnicity detection using the Sphinx III system, under Prof. K.R.Ramakrishnan,  
Dept of Electrical Engineering, Indian Institute of Science.**

This project involves constructing a test bed in Matlab, for the various properties of a channel, such as multi-path channel, fading channel or a noisy channel. The physical layer IEEE 802.11a standard was implemented, and the method of Orthogonal Frequency Division Multiplexing (OFDM) was evaluated in noise and multi-path channels.

TEACHING  
EXPERIENCE

Teaching Assistant for Advanced Digital Signal Processing, ECE Graduate course, CMU, Fall 2006.

SELECTED COURSES  
AND GRADES

**Carnegie Mellon University**

Fall 2005

10708 – Probabilistic Graphical Models – A

18792 – Advanced Digital Signal Processing – A

Spring 2005

18752 – Estimation, Detection and Identification – A

18794 – Pattern Recognition Theory – A

Fall 2004

18777 – Complex Large-Scale Dynamic Systems – A

21690 – Methods of Optimization – A

Spring 2004

15889 – Building Speech Recognition Systems – A-

18753 – Information Theory and Coding – A

Fall 2003

15681 – Artificial Intelligence: Machine Learning – A

18751 – Applied Stochastic Processes – B

PUBLICATIONS

- Y. Rachlin, Balakrishnan Narayanaswamy, R. Negi, J. Dolan, and P. Khosla, **Increasing Sensor Measurements to Reduce Detection Complexity in Large-Scale Detection Applications**, *Proceedings of the Military Communications Conference (MILCOM)*, 2006
- Balakrishnan Narayanaswamy, Rashmi Gangadharaiah, Richard Stern, **Voting for Two-Speaker Segmentation**, *Proc. of Interspeech, (ICSLP), Pittsburgh, PA*, September 2006
- R. Kerekes, B. Narayanaswamy, M. Beattie, B.V.K. Vijaya Kumar, and M. Savvides, **Multi-frame distortion-tolerant correlation filtering for video sequences**, *SPIE Defense and Security Symposium, Orlando, FL*, 2006
- B. Narayanaswamy and Rashmi Gangadharaiah, **Extracting Additional Information from Gaussian Mixture Model Probabilities for Improved Text Independent Speaker Identification**, *Proc. of Intl. Conf. on Acoustics, Speech, and Signal Processing, (ICASSP), Philadelphia, PA*, March 2005
- B. Narayanaswamy, **Improved Text-Independent Speaker Recognition using Gaussian Mixture Probabilities**, *Masters' Thesis, CMU*, 2005
- Rashmi Gangadharaiah, B. Narayanaswamy, N. Balakrishnan, **A Novel Method for Two-Speaker Segmentation**, *Proc. of Intl. Conf. on Speech and Language, (ICSLP), Jeju, Korea*, September 2004

UNDER  
PREPERATION

- B. Narayanaswamy, R. Kerekes, Jason Thornton, "Graphical Model Approach to Iris Matching Under Local Shifts and Occlusions",

REFERENCES

- Prof. Raj Reddy, Carnegie Mellon University.
- Prof. Pradeep Khosla, Carnegie Mellon University.
- Prof. Rohit Negi, Carnegie Mellon University.

OTHER DETAILS

- Nationality: Indian
- Visa Status: J1