Anand Panangadan

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Education

Ph.D., Computer Science 2002
University of California, Los Angeles
Advisor: Prof. Michael G. Dyer

M.S., Computer Science 1999
University of California, Los Angeles

B.Tech., Computer Science and Engineering 1996
Indian Institute of Technology, Bombay

Professional Experience

Research Specialist 2004- present
Saban Research Institute
Childrens Hospital Los Angeles

Post-doctoral Affiliate 2008- present
NASA Jet Propulsion Laboratory
California Institute of Technology

Post-doctoral Research Scholar 2003-2004
Computer Science Department
University of Southern California
Supervisors: Prof. Maja Mataric and Prof. Gaurav Sukhatme

Post-doctoral Research Scholar 2002-2003
Computer Science Department
University of California, Los Angeles
Supervisor: Prof. Adnan Darwiche

Research Experience

- **Body sensor networks for remote health monitoring**: At the Childrens Hospital Los Angeles, I am working on a wireless network of wearable medical sensors. The system can transfer sensor measurements to a remote health professional via the cellular network and over the Internet. This enables the wearer's health condition to be monitored continuously. I developed sensor control and signal processing algorithms for this system.
- **Coordination in sensor networks**: I am the co-PI on an NSF grant to explore the use of Markov Decision Processes and Kalman filters for distributed control in low-power sensor networks. The idea is to compute a control policy before deployment – the policy specifies the optimal sampling rate (and hence controls energy expenditure) for all possible run time states of the network of sensors.
- **Adaptive sampling in a coastal ocean sensor network**: The New York Harbor Observation and Prediction System (NYHOPS) is an operational network of coastal monitoring sensors coupled with a predictive model of ocean conditions. I developed an adaptive sampling

algorithm for the sensors so that the accuracy of the model forecasts could be increased by incorporating in-situ sensor measurements. This formalism could also determine the optimal parameters of other components in the network such as the sensor sampling rates, paths of unmanned underwater vehicles, and data transfer routes.

- **Tropical cyclone tracking from remote-sensed datasets**: At the Jet Propulsion Laboratory, I am developing a system that can autonomously track and predict the movement of tropical cyclones using data from remote-sensing satellites. Tracking of cyclones typically uses information from a variety of observations which are then interpreted by experts. By analyzing data from only remote-sensing satellites, this process can be completely automated. Date from different satellites is integrated in order to improve the temporal resolution of the cyclone tracking.
- **Distributed region detection for sensor networks**: I developed a distributed algorithm for region detection in sensor networks. A region is that area where all the sensors measure similar values. My distributed algorithm enables each sensor node to calculate the extent of the region in which it is located. The algorithm uses communication only between neighboring nodes. The calculated extent is updated as the region changes over time.
- **Tracking and modeling of human interactions**: For my post-doctoral research at USC, I developed probabilistic models of human movement, and especially of interactions between people. I tracked movements of people using laser range-finders. The tracks were divided into distinct activities using entropy-based segmentation. The activity segments were then combined to develop a probabilistic model of the observed activities. The models were then used for automatically detecting anomalous behavior.
- **Logical reasoning on embedded systems**: For my post-doctoral research at UCLA, I demonstrated that reasoning algorithms based on propositional logic could be executed even on low-power computing platforms if an efficient representation is used. I demonstrated the approach by programming a Sony Aibo robot to solve the "Wumpus world" problem. The plan to solve the problem was computed offline and stored as an Ordered Binary Decision Diagram in the robot's memory.
- **Construction by autonomous agents**: In my PhD dissertation research, I demonstrated how connectionist agents could construct arbitrary structures in a simulated environment. The goal was to build a group of autonomous agents that could rearrange objects in their environment to form arbitrary shapes. I achieved these objectives by coupling a behavior-based architecture with explicit spatial representation. The connectionist approach also facilitated different types of learning in the construction domain.

Teaching Experience

Teaching Assistant Coordinator 2001
Computer Science Department, UCLA

Teaching Assistant/Associate/Fellow
Computer Science Department, UCLA

- *Logic Design of Digital Systems* 1997-2001
- *Computer Systems Architecture* 1997, 2000
- *Digital Design Project Lab* 2000

Instructor
Center for Talented Youth (CTY), Johns Hopkins University

- *Theoretical Foundations of Computer Science* 1997

Academic Service

Program Committee member: Twentieth National Conference on Artificial Intelligence (AAAI 05), Workshop on Sensor Networks for Earth and Space Science Applications (ESSA) at IPSN 2009

Local Arrangements Committee member: International Joint Conferences on Artificial Intelligence (IJCAI 2009)

Judge: California State Science Fair 2004, 2007

Reviewer: IEEE Sensors Journal, IEEE Communications Magazine, International Journal of Computational Intelligence and Healthcare Informatics, IEEE Transactions on Image Processing, Journal of Applied Optics, International Journal of Social Robotics, International Conference on Data Mining, IEEE Aerospace Conference, IEEE/RSJ 2010 International Conference on Intelligent Robots and Systems

Students Advised

Shuping Liu
PhD student, Department of Electrical Engineering, USC

Refereed Publications

A. Panangadan and A. Talukder, Interleaving wavelet coefficients for adaptive data transmission from pervasive sensing systems, accepted to *International Conference on Computer Communication Networks (ICCCN)*, Maui, Hawaii, 31 July – 4 August, 2011.

S. Liu, **A. Panangadan**, C. Raghavendra, and A. Talukder, Learning a Policy for Coordinated Sampling in Body Sensor Networks, *Body Sensor Networks (BSN)*, Dallas, 23 – 25 May, 2011.

S. Liu, **A. Panangadan**, A. Talukder, and C. Raghavendra, Machine learning for automatic patient monitoring and prioritization using body sensor network systems, *18th Medicine Meets Virtual Reality International Conference (MMVR 18)*, Newport Beach, California, 8 – 12 February, 2011.

A. Talukder, **A. Panangadan**, N. Georgas, T. Herrington, and A. F. Blumberg, Integrated operational control of unattended distributed coastal sensor web systems with mobile autonomous robots. *Selected Topics in Applied Earth Observations and Remote Sensing, IEEE Journal of*, 3(4), pp. 442-450, 2010.

S. Liu, **A. Panangadan**, A. Talukder, and C. Raghavendra, Compact representation of coordinated sampling policies for body sensor networks, Workshop on Advances in Communication and Networks (Smart Homes for Tele-Health), *IEEE Global Communication Conference (GlobeCom)*, Miami, Florida, 6 – 10 December, 2010

A. Panangadan and A. Talukder, A variant of particle filtering using historic datasets for tracking complex geospatial phenomena, *18th ACM SIGSPATIAL International Conference*

on Advances in Geographic Information Systems, San Jose, 2 – 5 November, pp. 232-239, 2010.

A. Talukder and **A. Panangadan**, Integrating mobile robots with coastal sensor networks for marine event response management, Workshop on Robotics for Environmental Monitoring, *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, Taipei, 22 October, 2010.

A. Panangadan, M. Mataric and G. Sukhatme, Tracking and modeling of human activity using laser rangefinders. *International Journal of Social Robotics*, 2(1), pp. 95-107, 2010.

A. Panangadan, S. Ho, and A. Talukder, Cyclone tracking using multiple satellite image sources, *17th ACM SIGSPATIAL International Conference on Advances in Geographic Information Systems*, Seattle, 4 – 6 November, pp. 428-431, 2009.

S. Liu and **A. Panangadan**, Evaluation of a Markov Decision Process-based coordinated sampling method, Workshop on Sensor Networks for Earth and Space Science Applications, *8th ACM/IEEE International Conference on Information Processing in Sensor Networks (IPSN),* San Francisco, 16 April, 2009.

S. Liu, **A. Panangadan**, C. Raghavendra, and A. Talukder, Poster abstract: MDP framework for sensor network coordination, *8th ACM/IEEE International Conference on Information Processing in Sensor Networks (IPSN),* San Francisco, 13 – 16 April, 2009.

A. Talukder and **A. Panangadan**, Online visualization of adaptive distributed sensor webs, *IEEE Aerospace Conference*, Big Sky, Montana, 7 – 14 March, 2009.

A. Panangadan and M.G. Dyer, Construction in a simulated environment using temporal goal sequencing and reinforcement learning, *Adaptive Behavior*, 17(1), pages 81-104, 2009.

A. Talukder, **A. Panangadan**, A.F. Blumberg, T. Herrington, and N. Georgas, Improving the forecast accuracy of an ocean observation and prediction system by adaptive control of the sensor network, *Eos Trans. AGU*, 89(53), Fall Meeting Supplement, Abstract IN31A-1120, 2008.

A. Talukder, **A. Panangadan**, A. Blumberg, T. Herrington, and N. Georgas, Improving the science return from coastal sensor webs using autonomous predictive control and resource management. *Eighth Annual Earth Science Technology Conference*, University of Maryland, June 24 – 26, 2008.

A. Talukder, **A. Panangadan**, T. Herrington, A. Blumberg, and N. Georgas. Autonomous adaptive resource management in sensor network systems for environmental monitoring. In *IEEE Aerospace Conference*, Big Sky, Montana, 1 – 8 March, 2008.

M. Venugopal, K.E. Feuvrel, D. Mongin, S. Bambot, M. Faupel, **A. Panangadan**, A. Talukder, and R. Pidva. Clinical evaluation of a novel interstitial fluid sensor system for remote continuous alcohol monitoring, *IEEE Sensors Journal*, 8(1), pages 71-80, 2008.

A. Talukder, S. M. Ali, **A. Panangadan**, and L. Chandramouli. Predictive controller for heterogeneous sensor network operation in dynamic environments. In *Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems* (*IROS*), IEEE Press, pp. 1133-1139, 2005.

A. Panangadan, S. M. Ali and A. Talukder. Markov decision processes for control of a

sensor network- based health monitoring system. In *Proceedings of the Seventeenth Innovative Applications of Artificial Intelligence Conference (IAAI),* AAAI Press, Menlo Park, Calif., pp. 1529-1534, 2005.

A. Talukder, S. M. Ali, **A. Panangadan**, C. Jadhav, R. Pidva, R. Bhatt, L. Chandramouli, and S. Monacos. Optimal server scheduling and power management in sensor networks. In *Optical Pattern Recognition XVI, Proceedings of SPIE,* vol. 5816, pp. 221-232, 2005.

A. Panangadan, M. Mataric and G. Sukhatme. Identifying human interactions in indoor environments. In *Proceedings of the Third International Joint Conference on Autonomous Agents and Multi-Agent Systems (AAMAS)*, IEEE Computer Society, pp. 1308-1309, 2004.

A. Panangadan, M. Mataric and G. Sukhatme. Detecting anomalous human interactions using laser range-finders. In *Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems* (*IROS*), IEEE Press, pp. 2136-2141, 2004.

A. Panangadan and M.G. Dyer. Learning spatial and temporal correlation for navigation in a 2-dimensional continuous world. In *Proceedings of the 19th International Conference on Machine Learning (ICML)*, Morgan Kaufmann, pp. 474-481, 2002.

A. Panangadan and M.G. Dyer. Goal sequencing for construction agents in a simulated environment. In *Proceedings of the International Conference on Artificial Neural Networks (ICANN)*, Springer, pp. 969-974, 2002.

A. Panangadan and M.G. Dyer. Learning social behaviors without sensing. In *From Animals to Animats 7: Proceedings of the 7th International Conference on Simulation of Adaptive Behavior (SAB)*, Bradford Book/MIT Press, 2002.

A. Panangadan and M.G. Dyer. Construction by autonomous agents in a simulated environment. In *Proceedings of the International Conference On Artificial Neural Networks (ICANN)*, Springer, pp. 963-970, 2001.

G. Chao, **A. Panangadan** and M.G. Dyer. Learning to integrate reactive and planning behaviors for construction. In *From Animals to Animats 6: Proceedings of the 6th International Conference on Simulation of Adaptive Behavior (SAB)*, Bradford Book/MIT Press, pp. 167-176, 2000.

Non-refereed Publications

A. Panangadan and G. Sukhatme. Data segmentation for region detection in a sensor network. CRES Technical Report 05-005, University of Southern California, 2005.

A. Panangadan. Construction using autonomous agents in a simulated environment. PhD Thesis, Computer Science Department, University of California, Los Angeles, 2002.

Awards

NASA Space Act Award and Certificate of Recognition 2009
Online 3D Visualization of Large-Area Distributed Sensor Web Predictions for Coastal and Environmental Monitoring
NASA (Award #NPO 46899)

Co-Principal Investigator 2006
CSR-EHS: DEFT Distributed Embedded Fault-Tolerant

Control of Resource Constrained Sensor Networks
National Science Foundation (Award #0615132), $100,000

Conference Travel Grant 2002
19th International Conference on Machine Learning

Best Teaching Assistant Award 2001-2002
(both student and faculty nominated categories)
Computer Science Department, UCLA

Conference Travel Grant 2001
European Neural Network Society

Departmental Fellowship 1996-1997
Computer Science Department, UCLA

Certificate of Merit for Outstanding Academic Performance 1992
Central Board of Secondary Education, Government of India

Certificate of Honour, 7^{th} rank in the Physics Talent Test 1991
The Physics Society, Madras (Chennai), India