

# Balajee Kannan

rCommerce Lab  
Robotics Institute  
Carnegie Mellon University  
5000 Forbes Avenue  
Pittsburgh, PA 15213

Field Robotics Center  
Phone (O): (412) 268-9816  
Phone (C): (865) 803-1454  
Email: bkannan@cs.cmu.edu  
URL: <http://www.ri.cmu.edu/~bkannan>

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## OBJECTIVE

Distinguish myself as a researcher within the areas of intelligent systems, autonomous learning, distributed mobile robotics, human-agent interaction, and reliability utilizing abilities to:

- Collaborate and work on research projects in areas of expertise;
- Actively seek funding through proposal writing and presentation;
- Employ analytical skills to develop innovative solutions;
- Provide support as a technical team lead; and
- Continue the ongoing pursuit of knowledge.

## EDUCATION

- Ph.D., Computer Science, Spring 2007; GPA: 4.0  
“LeaF: A Learning-based Fault-diagnostic system for multi-robot teams”  
Advisor: Dr. Lynne Parker  
Distributed Intelligence Lab  
University of Tennessee, Knoxville
- M.S., Computer Science, Fall 2003; GPA: 3.78  
Advisor: Dr. Lynne Parker  
Distributed Intelligence Lab  
University of Tennessee, Knoxville
- B.E., Computer Engineering, Fall 2000; GPA: 3.7  
Advisor: Professor Mathiavanan  
University of Madras, India

## DISSERTATION

*“LeaF – A distributed Learning-based Fault-diagnostic system for multi-robot teams”*  
The objective of my dissertation, in part, is to provide an adaptive approach that enables the robot team to autonomously detect and compensate for the wide variety of faults that could be experienced. The key feature of the developed approach is its ability to learn useful information from encountered faults, unique or otherwise, towards a more robust system. In addition, the research attempts to identify the influence of fault-tolerance towards achieving overall system goals of efficiency and robustness. Towards that purpose, application-independent metrics to measure the system performance and fault-tolerance are developed.

## PROFESSIONAL EXPERIENCE

- **Carnegie Mellon University**, Pittsburgh, PA  
- *Research Engineer, Robotics Institute*, April 2007 - present  
Duties involve design and development of experimental hardware/software applications as well as modifying and maintaining existing systems for robotic research. In addition, responsible for developing requirement specifications for integration with mechanical system/components, providing in-depth documentation and instruction to other

researchers about system capabilities, and analyzing new routines and system changes in consultation with project managers, principal investigators and other researchers. Other responsibilities include supervising interns in their day to day responsibilities and to help introduce them to the fundamental concepts of scientific research.

**Projects:**

- *“Dynamic Human-Robot Teams Engaged in Complex Adversarial Tasks Using Language Based Communication”*, rCommerce Lab, Robotics Institute, CMU

Dynamic team formation addresses the problem of forming teams of robots (pioneers, ER1s, LAGRs, and Segways) and humans operating in a complex environment, indoor or outdoors, in a manner where both human and robot team members may have only minimal knowledge of each other’s behavior.

- *“Coordinating Human-Robot Teams in Unstructured Environments”*, rCommerce Lab, Robotics Institute, CMU

We propose to develop algorithms for coordinating heterogeneous teams in large-scale distributed operations where: • Teams consist of humans, robots, and software agents • Tasks range from single-agent distributed tasks to tightly-coupled team-tasks • Software agents will monitor operations, control access to restricted resources, act as interface agents for human team members, etc, and • Humans and robots will be team members with dynamic sub-team assignments, dynamic hierarchies, and dynamic role assignments

- *Evaluation Methodology for Peer-to-Peer Human-Robot Teams*, rCommerce Lab, Robotics Institute, CMU

We propose a set of qualitative and analytical metrics that can be used to analyze, and subsequently improve, team performance. A unique feature of the proposed set of metrics is that they are designed on a sliding scale of analysis that provides the user the with flexibility to control the depth of analysis. The three stage analysis process can be divided into: *pre-execution* stage involving an initial assessment of the execution strategy, followed by a fast, feedback-based, *on-line evaluation* of key system characteristics, and a finally an in-depth *post-execution* analysis, leading to a better understanding of the system as a whole.

- *Map-based localization*, rCommerce Lab, Robotics Institute, CMU

The goal of the project is to produce a probability estimate of the position of an outdoor vehicle traversing from point A to point B at any point in its path using the vehicles motion and navigation information combined with pre-registered aerial imagery of the operating environment.

- *Designing large outdoor vehicle test-bed*, rCommerce Lab, Robotics Institute, CMU

Towards developing a stable platform for testing single and multi-robot behaviors in harsh outdoor environments, I am responsible for re-designing our existing e-gator robot platform. The new design includes adding additional sensing and hardware equipment while streamlining existing sensing capabilities. In addition, I am responsible for developing software for tightly integrating the new sensors into the existing systems to provide a reliable platform for behavior testing and a comprehensive new logging system for detailed analysis of system behavior.

• **University of Tennessee, Knoxville**

- *Research Assistant, Distributed Intelligence Lab*, May 02 to April 07

**Projects:**

*“DARPA SDR Project: Experiments with a Large-Scale Heterogeneous Mobile Robot Team for Search Applications”*, DI Lab Developed behavior based autonomous robot

control code using C++. Solely responsible for designing and developing software fault tolerance for a team of 100 robots including ATRV-Minis, Pioneers and AmigoBots using laser-based localization and vision-based navigational assistance. Responsible for designing and developing software for the communication and vision-based coordination of multi-robot teams using ad-hoc mobile networks.

- *Teaching Assistant*, **Department of Computer Science**, Jan 05 to present

Responsible for design, development and maintenance of internal recruitment database (front end PHP; backend MySQL). In 2005, prepared and graded assignments, exams and conducted office hours for “CS380 - Theory of Computation”, an advanced undergraduate course that covers basics of theoretical computer science and computational models including Finite Automata, PDA, Turing machines, Decidability, Rice’s Theorem etc. In 2004, was responsible for preparing and grading labs, assignments and exams, in addition to conducting office hours, for “CS102 - Introduction to programming in C”, an undergraduate course.

- *Instructor*, **Department of Computer Science**, Sep 04 to Dec 04

Course: “CS300 - Scripts and Utilities”, an undergraduate level course to teach many of the practical tools available under Unix like Perl, Awk, Python, PHP, L<sup>A</sup>T<sub>E</sub>X, CVS etc. Gave lectures, prepared and graded labs, and conducted office hours. In addition, designed and updated existing course curriculum.

- *UNIX/LINUX Systems Admin*, **Office of Information Technology**, May 01 to Aug 02

Responsible for maintaining numerous Linux and Solaris servers. Other responsibilities included trouble-shooting Linux and Solaris desktop systems, installing and maintaining oracle database servers, maintaining CGI, PHP and HTML based web-pages for internal and external systems.

- *Research Assistant*, **Software Quality Research Lab**, May 01 to Aug 01

Worked on building statistical tools for automated testing, specifically on “TMLE The Modeling Language Editor”.

- *Research Assistant*, **Innovative Computing Lab**, Aug 00 to May 01

Was part of the IBP (Internet Backplane Protocol) project and handled the design and implementation of UDP-File blasters for faster data-transfer. Had the opportunity to work on “Ex-node” for IBP and LOCI.

#### ● **Evolution Robotics**

- *Intern*, May 05 to Aug 05

Worked with Dr. Mario Munich and Dr. Jim Ostrowski towards developing a Kalman filter system for sensor-fusion and noise elimination from a proprietary infrared based positioning device for fast and stable indoor localization. Other responsibilities included performing quality analysis for Evolution robotics SDK, ERSP (ver 2.0). Specifically, was expected to evaluate the performance of the vision-based mapping and localization software.

#### ● **University of Madras, India**

- *Research Assistant*, Dec 99 to June 00

Worked on an *AICTE: All India Council for Technical Education* funded project, “Non-invasive diagnostic system for medical prognosis” using neural nets, fuzzy logic and genetic algorithms. Developed system for automating traditional medical approach for more efficient diagnosis using neural networks and genetic algorithms.

- BOOK CHAPTERS
- L. Parker, and B. Kannan, “Using Causal Models for Fault-Diagnosis in Multi-robot Teams — A Feasibility Study,” (*To be published in Search and Rescue Robotics*).
- JOURNAL PUBLICATIONS
- B. Kannan, M. Bernardine Dias and L. Parker, “A Framework for Evaluating Team Performances in Dynamic Domains,” (*in preparation*).
  - B. Kannan, and L. Parker, “Adaptive Causal Models for Fault Diagnosis and Recovery in Multi- Robot Teams,” (*in preparation*).
- REFEREED CONFERENCE PROCEEDINGS
- B. Kannan and M. Bernardine Dias, “Evaluating Team Performance in Dynamic Domains,” *under review in Field and Service Robotics (FSR), 2009*.
  - B. Kannan, M. Bernardine Dias, and E. Gil Jones, “A case study for complex heterogeneous human-robot peer-to-peer teams operating in a unstructured environment,” *in preparation, 2009*.
  - M. Bernardine Dias, B. Kannan, Brett Browning, E. Gil Jones, Brenna Argall, M. Freddie Dias, Marc Zinck, Manuela M. Veloso, and Anthony J. Stentz, “Sliding Autonomy for Peer-To-Peer Human-Robot Teams,” *Proceedings of International Conference on Intelligent Autonomous Systems (IAS)*(Acceptance rate of less than 50%), 2008.
  - B. Kannan, and L. Parker, “Metrics for quantifying system performance in intelligent, fault-tolerant multi-robot teams,” *Proceedings of IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)* (One of the top 2 conferences in the robotics field with an acceptance rate of 43%), 2007.
  - L. Parker, and B. Kannan, “Adaptive Causal Models for Fault Diagnosis and Recovery in Multi- Robot Teams,” *Proceedings of IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2006.
  - L. Parker, B. Kannan, F. Tang and M. Bailey, “Tightly-Coupled Navigation Assistance in Heterogeneous Multi-Robot Teams,” *Proceedings of IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2004.
  - L. Parker, B. Kannan, X. Fu and Y. Tang, “Heterogeneous Mobile Sensor Net Deployment Using Robot Herding and Line-of-Sight Formations,” *Proceedings of IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2003.
- REFEREED WORKSHOP PAPER
- B. Kannan, and L. Parker, “Fault-Tolerance Based Metrics for Evaluating System Performance in Multi-Robot Teams,” *Proceedings of Performance Metrics for Intelligent Systems Workshop (PerMIS)*, 2006.
- INVITED TALKS
- “Autonomy for fault-tolerance in multi-robot teams,” Guidance, Control, and Decision Systems Laboratory (GCDSL), Department of Aerospace Engineering, Indian Institute of Science, August 11, 2008, Bangalore, India.

- “Developing a Generic Fault-Tolerance Architecture for Multi-Robot Teams,” Center for Intelligent Systems, Vanderbilt University, October 27, 2006, Nashville, TN.

## PRESENTATIONS

- “Sliding Autonomy for Peer-To-Peer Human-Robot Teams,” *International Conference on Intelligent Autonomous Systems (IAS)*, July 2008, Baden Baden, Germany.
- “Fault-Tolerance Based Metrics for Evaluating System Performance in Multi-Robot Teams,” *Performance Metrics for Intelligent Systems Workshop (PerMIS)*, 2006, Gaithersburg, MD.
- “Heterogeneous Mobile Sensor Net Deployment Using Robot Herding and Line-of-Sight Formations,” *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2003, Las Vegas, NV.
- “Robot Control”, guest speaker for “CS 594, Artificial Intelligence,” 2004, Knoxville, TN, Instructor: Professor Lynne E. Parker.
- “Good practice methods to prepare for a successful career in research,” Sathyabama Engineering College, 2001, Chennai, India.
- “Studying abroad - Opportunities and difficulties,” Farragut High School, 2000, Farragut, TN.

## DEMO AND VIDEOS

- “Dynamic Human-Robot Teams Engaged in Complex Adversarial Tasks Using Language-Based Communication,” Demonstration performed by a team comprising of *rCommerce Lab*, *CORAL* and *Language Technology Institute* of Carnegie Mellon University, 2007, Robotics Institute, CMU, Pittsburgh.
- “DARPA/SDR Project Demonstration – large numbers (100+) of physical heterogeneous robots cooperating to solve indoor search applications,” Demonstration performed by a team comprising of Distributed Intelligence Lab (University of Tennessee), SAIC and Robotics Lab of USC, 2004, Mclean, VA.
- “Heterogeneous Mobile Sensor Net Deployment Using Robot Herding and Line-of-Sight Formations,” L. Parker, B. Kannan, X. Fu and Y. Tang, *in IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2003, Las Vegas, NV.

## STUDENTS

- Victor Marmol - sophomore, Robotics Institute, Carnegie Mellon University. Intel IFYRE fellowship grant awardee for Spring and Fall 2008, SURG summer fellowship awardee for Summer 2008.
- Nisarg Kothari - junior, Robotics Institute, Carnegie Mellon University. SURG fellowship awardee for 2008-2009.
- Brad Neuman - senior, Robotics Institute, Carnegie Mellon University.

## SPECIAL SKILLS

- **Spoken Languages:** English, Hindi, and Tamil.
- **Programming:** C, C++, Matlab, Java, Java Swing, FLTK, Open-GL, Pascal, FORTRAN, Visual Basic.
- **Database:** Oracle, Excel, SQL, my-SQL.
- **Scripts:** Perl, PHP, Bash, Csh.
- **OS:** Windows 95, 98, NT, Win2K, XP, Sun-Solaris (7.0, 8.0, 9.0), Linux (Red-Hat, Mandrake, SUSE, Debian, Gentoo), Arm Linux for IPAQ, VMWARE for Linux, OS X Tiger, and OS X Leopard.
- **Web Design:** HTML, DHTML, CGI (with Perl) and CGIC.
- **Protocols:** DNS and BIND.
- **Robotic Platforms:** Player-Stage, Evolution Robotics Software Package (ERSP), Nomad200 Robot Simulator, Mobility software.
- **Robot Hardware:** ATRV-Minis, Pioneers (2dx and 3dx), LAGRs, E-Gators, ER-1s, Amigo Bots and Nomads.
- **Sensors:** SICK LMS 100 and 200, SONARS, KVH E-Core 100, DSP3000 FOGs, Xsens 6-axis IMU, CMU cams, Crossbow IMU440 series.
- Expert knowledge of the professional typesetting package  $\text{\LaTeX}$ .
- Strong writing, grammar, and linguistic skills.
- Strong graphic-design skills useful in presentations, publications, and schematics.

## HONORS AND MEMBERSHIPS

- Chancellor's citation for Extraordinary Professional Promise (2007, University of Tennessee).
- The National Scholars Honor Society.
- UPSILON PI EPSILON (UPE) – Computer Science Honor Society.
- SIGMA XI – Scientific Research Society.
- Member of ACM.
- Member of the Robotics chapter of IEEE.
- Secretary for CSI (Computer Society for India), 1999.

- Served the Army wing of National Cadet Corps of India (91 Battalion) honorably for a period of 2 years (94,95).
- Member of the College Cricket team, winner of the Sathyabama Cricket Trophy, awarded to “Best Team” among professional colleges in the state of Tamil Nadu, in 97, 98 and 00.

RELEVANT COURSE WORK • *Artificial Intelligence, Software for Distributed Robotics, Distributed Intelligence in Autonomous Robotics, AI Analysis, Advanced Topics in AI, Foundations of Computer Theory and Algorithms, Markov Chains, Software Engineering.*

REVIEWER FOR PUBLICATIONS:

- International Joint Conferences on Artificial Intelligence, 2009.
- RoboCup, 2009.
- IEEE Transactions on Systems, Man, and Cybernetics, 2006 - present.
- Journal of Robotics and Autonomous Systems, 2005.
- IEEE International Conference on Robotics and Automation (ICRA), 2006-2007.
- IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2005-2009.
- ACM Reviewer for Computing Reviews, 2006 - present.
- IEEE Network Magazine, 2006 - present.
- IEEE Network Special Issue on Wireless Sensor Networking, 2006 - present.

ACADEMIC OUTREACH SERVICES

- Executive member, “Cricket Cares” – A non-profit organization that is actively involved in providing education for under-privileged children, 2007 - present.
- Judge, East Tennessee FIRST (For Inspiration and Recognition of Science and Technology) LEGO League Robotics State Tournament, 2006.
- Visits of Robertsville Middle School students to the University of Tennessee, 2005, Knoxville.
- University of Tennessee Pre-Game Faculty Showcase Lecture, 2004, Knoxville.

OTHER ACTIVITIES

- Member PCA – Pittsburgh Cricket Association, 2007 - present.
- Member USTA – United States Tennis Association, 2006 - present.
- Member SCCA – Southern California Cricket Association, 2005.
- Member ADC – Apple Developer Connection, 2004 - present.

- Treasurer, Manthan – The Indian Students Organization at University of Tennessee, Knoxville, 2002.
- Founder and member of Manthan’s cricket team, 2000 - 2007.

REFERENCES

Lynne E. Parker, Ph.D.  
Distributed Intelligence Lab  
University of Tennessee  
865-974-4394  
parker@cs.utk.edu

Tony Stentz, Ph.D.  
Research Professor/Assoc Dir NREC  
Robotics Institute  
Carnegie Mellon University  
412-268-8155  
axs@rec.ri.cmu.edu

M. Bernardine Dias, Ph.D.  
Director, TechBridgeWorld  
Assistant Research Professor  
Robotics Institute  
Carnegie Mellon University  
412-268-9365  
mbdias@ri.cmu.edu

CITIZENSHIP

Indian