Niranjini Rajagopal

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About

I have 12+ years of experience in networked embedded sensing systems research and engineering. I enjoy experimenting with sensing systems and designing sensor data processing algorithms. I have worked with various sensing modalities including electric and magnetic field, current and voltage, visible light, inertial, ultrasonic, and wireless sensing. I have an aptitude to work across different layers of the distributed sensing system stack, with focus close to the physical layer. My PhD was in indoor localization. I deployed and evaluated all my indoor localization solutions in the real-world. My work won the Microsoft International Indoor Localization Competition twice, with two different sensing systems.

Education

July 2019 **Carnegie Mellon University (CMU)**, *Ph.D.*, Electrical and Computer Engineering.
Thesis: Localization, Beacon Placement and Mapping for Range-Based Indoor Localization Systems
Advisors: Prof. Anthony Rowe, Prof. Bruno Sinopoli. Committee: Prof. Prabal Dutta, Dr. Brent Ledvina

2011 – 2012 **Carnegie Mellon University (CMU)**, *M.S.*, Electrical and Computer Engineering.

2004 – 2008 **National Institute of Technology Tiruchirappalli (NITT), India**, *B.Tech.*, Electronics and Communication Engineering.

Industry Experience

Aug 2019 onwards **Amazon**, *Devices organization*.
- Working on a new technology initiative in a new area of focus for Amazon.

Summer 2015 **Apple Inc.**, *Wireless Location Team*, Mentor: Dr. Brent Ledvina.
- Worked on the earliest experiments, prototype and preliminary modeling of time-of-flight RF ranging technology in the location team, and was selected to present the work and *demonstrate a prototype* to Craig Federighi, SVP of Software Engineering, Apple. Subsequently, this resulted in the Apple Auto Unlock feature.

Summer 2013 **Texas Instruments, Dallas**, *Embedded Processing Team*, Mentors: Dr. Srinath Hosur, Dr. Ariton Xhafa, Hybrid communication over power line and WiFi.
- Analyzed the feasibility of integrating wireless and power line communication technologies. Designed and simulated co-existence of both technologies at the MAC and PHY layer.

Aug'09 – Jul'11 **Signals & Systems India Pvt. Ltd., Chennai, India**, Role: R&D Engineer, Project: Embedded products for power sector, with focus on embedded software.
- Designed energy metering products (Reference energy meters, multi-function transducers), with focus on embedded software. Involved in entire product development process from customer specification to field deployment in collaboration with hardware, production and customer support teams. Mentored new R&D engineers and trained customer support engineers. Revamped sensor calibration processes, reducing the production line time by 60%.

Jun'08 – Jul'09 **Analog Devices Inc., Bangalore, India**, Role: IC Design Engineer in the SHARC DSP Group, Project: SHARC 2146x-2148x verification.
- Implemented test plan for the Variable Instruction Set Architecture, verified Core and IOP modules at the RTL and Gate Level.

Selected Awards

2019 **Runner-up Best Paper Award**, International Conference on Indoor Positioning and Indoor Navigation

2018 **Among MIT EECS Rising Stars**

2018 First place in Microsoft Indoor **Localization Competition** in 3D Infrastructure-based category

2018 **Best Demo** Award, International Conference on Information Processing in Sensor Networks

2017 Ben Taskar Memorial **Best Poster** Award, TerraSwarm Annual Review

2016 – 2017 Samsung Ph.D. **Fellowship (among 5 students in US)**, for Internet of Things area

2015 – 2016 Carnegie Mellon William S. Dietrich II **Presidential Ph.D. Fellowship**

2015 First place in Microsoft Indoor **Localization Competition** in 2D Infrastructure-based category

2014 Fourth place in Microsoft Indoor **Localization Competition** in 2D Infrastructure-based category

2013 – 2014 Carnegie Institute of Technology Dean's Tuition **Fellowship**

2014 Networking Networking (N2) **Women Young Researcher** Fellowship award for CPS Week

2011 Narotam Sekhsaria Foundation **Scholarship** for Higher Studies, India (among 12 students in India)

Publications

SIGSPATIAL '19 Haotian Wang, Niranjini Rajagopal, Anthony Rowe, Bruno Sinopoli, and Jie Gao, **Efficient Beacon Placement Algorithms for Time-of-Flight Indoor Localization**, The 27th ACM SIGSPATIAL International Conference on Advances in Geographic Information Systems, Chicago, USA, 2019

IPIN '19 Niranjini Rajagopal, John Miller, Krishna Kumar Reghu Kumar, Anh Luong, and Anthony Rowe, **Improving Augmented Reality Relocalization Using Beacons and Magnetic Field Maps**, The 10th International Conference on Indoor Positioning and Indoor Navigation, Pisa, Italy, 2019

IPSN '18 Niranjini Rajagopal, Patrick Lazik, Nuno Pereira, Sindhura Chayapathy, Bruno Sinopoli and Anthony Rowe, **Enhancing Indoor Smartphone Location Acquisition using Floor Plans**, The 17th International Conference on Information Processing in Sensor Networks, Porto, Portugal, 2018

RTAS '17 Adwait Dongare, Patrick Lazik, Niranjini Rajagopal, Anthony Rowe, **Pulsar: A Wireless Propagation-Aware Clock Synchronization Platform**, 23rd IEEE Real-Time and Embedded Technology and Applications Symposium, Pittsburgh, USA, 2017

IPIN '16 Niranjini Rajagopal, Sindhura Chayapathy, Bruno Sinopoli, Anthony Rowe, **Beacon Placement for Range-Based Indoor Localization**, The 7th International Conference on Indoor Positioning and Indoor Navigation, Madrid, Spain, 2016

SenSys '15 Patrick Lazik, Niranjini Rajagopal, Oliver Shih, Bruno Sinopoli, Anthony Rowe, **ALPS: A Bluetooth and Ultrasound Platform for Mapping and Localization**, The 13th ACM Conference on Embedded Networked Sensing Systems, Seoul, South Korea, 2015

IPSN '15 Lymberopoulos et al., **A Realistic Evaluation and Comparison of Indoor Location Technologies: Experiences and Lessons Learned**, ACM/IEEE 14th International Conference on Information Processing in Sensor Networks, Seattle, USA, 2015

RTAS '15 Patrick Lazik, Niranjini Rajagopal, Bruno Sinopoli, Anthony Rowe, **Ultrasonic Time Synchronization and Ranging on Smartphones**, 21st IEEE Real-Time and Embedded Technology and Applications Symposium, Seattle, USA, 2015

VLCS '14 Niranjini Rajagopal, Patrick Lazik, Anthony, Rowe, **Hybrid Visual Light Communication for Cameras and Low-Power Embedded Devices**, 1st ACM Workshop on Visible Light Communication Systems, Maui, USA, 2014

IPSN '14 Niranjini Rajagopal, Patrick Lazik, Anthony Rowe, **Visual Light Landmarks for Mobile Devices**, ACM/IEEE International Conference on Information Processing in Sensor Networks, Berlin, Germany, 2014

RTSS '13 Maxim Buevich, Niranjini Rajagopal, Anthony Rowe, **Hardware Assisted Clock Synchronization for Real-Time Sensor Networks**, IEEE Real-Time Systems Symposium, Vancouver, Canada, 2013

ICCPS '13 Niranjini Rajagopal, Suman Giri, Mario Berges, Anthony Rowe, **A Magnetic Field-based Appliance Metering System**, The 4th ACM/IEEE International Conference on Cyber-Physical Systems, Philadelphia, USA, 2013

VLSID '09 Ramasamy, S., B. Venkataramani, R. Niranjini, and K. Suganya. **100KHz-20MHz Programmable Subthreshold $\mathbf{G_m - C}$ Low-Pass Filter in $\mathbf{0.18\mu m}$ CMOS**. In 2009 22nd International Conference on VLSI Design, pp. 105-110. IEEE, 2009

Patents

2017 **Method and Apparatus for Locating a Mobile Device within an Indoor Environment**. Patrick Lazik, Niranjini Rajagopal, Oliver Shih, Anthony Rowe, Bruno Sinopoli - US Patent 9,766,320, 2017

Research at CMU

2014 onwards **Indoor localization *(Focus of thesis)***.

- Designed and implemented novel localization techniques and algorithms by integrating information from range-based beacons, floor plan geometry, and sensors on mobile devices, to create range-based localization systems that are robust to non line-of-sight signals, operate with low-density beacons, and provide instant location and orientation acquisition on mobile devices.
- Developed tools for automating beacon placement given a floor plan and designed and implemented algorithms for pedestrian-aided beacon-mapping using range-only simultaneous localization and mapping algorithms.
- Contributed to the design of a novel ultrasonic time-of-flight localization processing platform. This has now spun into a startup, Yodel Labs.
- Implemented and demonstrated proposed localization solutions applied to persistent multi-user mobile augmented reality and an infrastructure-free localization system for firefighters.
- Evaluated performance of designed systems with real world deployments with ultrasonic beacons, ultra-wideband beacons and Bluetooth Low Energy beacons.

2013 – 2014 **Visible light communication (VLC)**.

- Designed a communication system between LED lights and rolling-shutter based camera devices.
- Extended to a hybrid communication scheme for smartphones and low-power embedded tags.

2012 – 2013 **Ambient electric and magnetic field sensing systems**.

- Designed a magnetic field-based wireless sensor networking system, three-phase energy metering platform and estimation algorithms for non-intrusive load disaggregation of electrical appliances.
- Designed a hardware-based clock tuning circuit, which leverages ambient electric and magnetic fields emitted from power lines.

Summer 2012 **Sensor data processing for smart buildings**, *Summer internship*, Mentor: Prof. Rohit Negi.

- Designed statistical signal processing-based algorithms for processing data from wireless environmental sensors for prediction and actuation in smart buildings.

2011 – 2012 **Three-phase energy meter design and data modeling**.

- Designed embedded software for a real-time wireless three-phase energy meter, deployed in a micro-grid in Haiti.

Selected Demonstrations

Army AI '19 Niranjini Rajagopal, John Miller, Anh Luong, Anthony Rowe, **An Interactive Infrastructure-Free Indoor Localization System for Firefighters**, One of the four demos in CMU for CMU & Army AI Hub event, Feb, 2019 (not peer-reviewed)

NIST '18 Niranjini Rajagopal, John Miller, Anh Luong, Anthony Rowe, **An Infrastructure-Free Localization System for Firefighters**, Public Safety Broadband Stakeholder Meeting, organized by NIST, San Diego, USA, 2018 (not peer-reviewed)

IPSN '18 Niranjini Rajagopal, John Miller, Krishna Kumar, Anh Luong, Anthony Rowe, **Demo Abstract: Welcome to My World: Demystifying Multi-user Augmented Reality with the Cloud**, The 17th International Conference on Information Processing in Sensor Networks, Porto, Portugal, 2018

IPIN '16 Niranjini Rajagopal, Sindhura Chayapathy, Bruno Sinopoli, Anthony Rowe, **A Toolchain for Beacon Placement for Range-Based Indoor Localization**, The 7th International Conference on Indoor Positioning and Indoor Navigation, Madrid, Spain, 2016 (not peer-reviewed)

SenSys '15 Patrick Lazik, Niranjini Rajagopal, Oliver Shih, Bruno Sinopoli, Anthony Rowe, **Demo Abstract: Where Am I And Where Are The Walls?**, The 13th ACM Conference on Embedded Networked Sensor Systems, Seoul, South Korea, 2015

IPSN '14 Niranjini Rajagopal, Patrick Lazik, Anthony Rowe, **Demo Abstract: How Many Lights do You See?**, in Proceedings of the 13th ACM/IEEE International Conference on Information Processing in Sensor Networks, Berlin, Germany,2014

ICCPS '13 Niranjini Rajagopal, Suman Giri, Mario Berges, Anthony Rowe, **Demo Abstract: Magnetic Field-based Appliance Metering System**, The 4th ACM/IEEE International Conference on Cyber-Physical Systems, Philadelphia, USA, 2013

Selected Workshops

KTH '18 Smart Cities Summer School, organized by Integrated Transport Research Lab, at KTH Royal Institute of Technology, Sep 2018

USC '18 Mixed Reality Workshop, organized by CONIX Research Center, at Institute for Creative Technologies, University of Southern California, Aug 2018

UCLA '18 Enhanced Situational Awareness Workshop, organized by CONIX Research Center, at University of California Los Angeles, Aug 2018

VLCS '14 1st ACM Workshop on Visible Light Communication Systems (VLCS), in conjunction with MobiCom, Sep 7, 2014, Maui, Hawaii. **(Poster: Is There a Place for VLC in Wireless Sensor Networks?**

UMich '14 Indoor localization Workshop, organized by the TerraSwarm Research Center, at University of Michigan, May 2014 **(Poster: Visible Light Landmarks for Phones and Low-Power Sensors)**

CMU '14 Open Building Automation Systems Workshop, organized by DOE Building Technologies Office Project, at CMU, Nov 2014 **(Poster: Solid-State Lighting for Sensor Mapping)**

Invited Talks

FRL **Towards Location-Aware Computing**, Facebook Reality Labs, Apr 2019

Amazon **Towards Location-Aware Computing**, Amazon, Apr 2019

MSR **Towards Location-Aware Computing**, Microsoft Research, India, Apr 2019

UTA **Location, location, location! A key primitive for Cyber-Physical Systems**, University of Texas at Austin, Apr 2019

UVA **Location, location, location! A key primitive for Cyber-Physical Systems**, University of Virginia, Charlottesville, Mar 2019

Cornell **Location, location, location! A key primitive for Cyber-Physical Systems**, Cornell University, Feb 2019

CyLab **Augmented Reality meets Internet-of-Things**, CyLab Partners Conference, Pittsburgh, Sep 2018

CONIX **Mobile Augmented Reality**, CONIX Annual Review, Pittsburgh, Sep 2018

Magic Leap **Towards Location-Aware Computing**, Magic Leap, Seattle Sep 2018

Amazon **Towards Location-Aware Computing**, Amazon, Seattle, Sep 2018

Intel **Towards Location-Aware Computing**, Intel Labs, Santa Clara, Sep 2018

COMPASS **The Current Status of Research on Mobile Location Aware Technology**, Conference on Mobile Position Awareness Systems and Solutions, San Francisco Exploratorium, Sep 2018

ETH **Where am I? A Sensor-Fusion Approach to Indoor Localization**, ETH Zurich, June 2018

KTH **Where am I? A Sensor-Fusion Approach to Indoor Localization**, KTH Royal Institute of Technology Stockholm, June 2018

IPSN **Enhancing Indoor Smartphone Location Acquisition using Floor Plans**, The 17th International Conference on Information Processing in Sensor Networks, Porto, Portugal, April 2018

IPIN **Beacon Placement for Range-Based Indoor Localization**, The 7th International Conference on Indoor Positioning and Indoor Navigation, Madrid, Spain, Oct 2016

ETH **Automatic Placement and Mapping of Beacon-based Localization Systems**, ETH Zurich, Oct 2016

CyLab **Grappling with Billions of Devices - A Step Towards Spatially-Aware IoT**, CyLab Partners Conference, CMU, Sept 2016

Samsung **Sensor Fusion and Automatic Infrastructure Mapping for Indoor Localization Systems**, Samsung, San Jose, March 2016

MSR **Smartphone-based Indoor Localization**, Microsoft Research, Bangalore, India, May 2015

IISc **Smartphone-based Indoor Localization**, Robert Bosch Center for Cyber-Physical Systems, Indian Institute of Science, Bangalore, India, May 2015

SII **Smart Lighting: Technology and Applications for Building Automation**, Carnegie Mellon Smart Infrastructure Institute (SII), Dec 2014

VLCS **Hybrid Visible Light Communication for Cameras and Low-Power Embedded Devices**, 1st ACM Workshop on Visible Light Communication Systems Workshop, Maui, USA, Sep 2014

IPSN **Visual Light Landmarks for Mobile Devices**, 13th ACM/ IEEE International Conference on Information Processing in Sensor Networks, Berlin, Germany, Apr 2014

ICCPS **A Magnetic Field-based Appliance Metering System**, 4th ACM/IEEE International Conference on Cyber-Physical Systems, Philadelphia, USA, Apr 2013

Teaching

Fall 2018 **Introduction to Embedded Systems, Guest Lecturer**, *ECE, CMU*.

Spring 2017 **Wireless Networks and Applications, Teaching Assistant**, *18452/18750: ECE, CMU*.

Spring 2015 **Signals and Systems, Teaching Assistant**, *18290: ECE, CMU*.

Fall 2012 **Signals and Systems, Teaching Assistant**, *18290: ECE, CMU*.

Jan'15 - Jan'19 **Eberly Center for Teaching Excellence and Educational Innovation, Graduate Teaching Fellow**, *CMU*.

- Supported the professional development of the CMU graduate student community as a teaching peer consultant, by providing classroom observations, facilitating workshops, and providing feedback on teaching strategies. Gained deeper professional development in pedagogy through consultation training, and pedagogical reading and discussions.

Students Mentoring

May '17-'18 **Enhancing augmented reality on iOS with sensors**, *Krishna Kumar*, MS ECE, CMU.

Jan-May '17 **Fusion of IMU with acoustic ranging**, *Nikhil Choudhary*, BS ECE, CMU.

May '15-'16 **Integration of floor plan for range-based localization**, *Sindhura Chayapathy*, MS ECE, CMU.

Professional Service and Leadership

2022	Co-organizer, Tutorials, 4th International Conference on COMmunication Systems & NETworkS (COMSNETS)
2021	Technical Program Committee Member, Indoor Positioning and Indoor Navigation Conference
2019	Member, Carnegie Mellon University Academic Advising Award Committee
2017	Student volunteers leader, CPS Week 2017, Pittsburgh, PA
2015	Student organizer, Workshop on Wearable Systems and Applications, co-located with MobiSys
2015	Shadow Technical Program Committee member, IPSN
2014	Organizer, N2 (Networking Networking) event for women researchers at CPS Week
2014 – 2016	Organizer, CyLab student seminar series
2012 – 2013	Vice President, ECE Masters Students Advisory Council
2014 onwards	Reviewer - IEEE Wireless Communications Magazine '14, Conference on Decision and Control '14 (External), CoNEXT '15 (External), IEEE ICC Optical Wireless Comm. Workshop '16, IEEE Transactions on Signal Processing '16, IEEE Transactions on Mobile Computing '16 & '17, Symposium on Wireless Personal Multimedia Communications '17, IEEE Wireless Communications Magazine '17, IEEE Vehicular Technology Conference '18, IEEE Communications Letters '18, IEEE Sensors Journal '18, IEEE Access '18, Transactions on Sensor Networks '18

K-12 Outreach at CMU

2014 – 2016	Co-chair ECE Outreach Mobile Labs, CMU. Expanded ECE Outreach program to high-schools. Initiated pilot program with Oakland Catholic Girls High School, Pittsburgh in Spring 2015
2013 – 2016	Teaching Assistant, ECE Outreach Spark Saturdays Program, CMU. Assisted in introductory electrical and computer engineering classes for grade 9-12 students
2013 – 2014	Volunteer, Middle/High School Days, Society of Women Engineers
Aug'12 – Jul'14	Volunteer, Carnegie Mellon Institute for Talented Elementary and Secondary Students (C-MITES). Assisted in mathematics, robotics and science hands-on classes for grade 1-5 students