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Rahul Bhattacharyya

Education

- **Massachusetts Institute of Technology, Cambridge MA** June 2012
  Doctor of Philosophy, Civil and Environmental Systems Engineering
- **Indian Institute of Technology (IIT) Bombay, India** August 2006
  Bachelor of Technology (B.Tech) and Master of Technology (M.Tech), Civil Engineering
  M.Tech Specialization: Structural Engineering

Current Role

Director, MIT Auto-ID Labs, Cambridge MA June 2022 - Present
Responsibilities include research portfolio management, developing multidisciplinary approaches to solve engineering problems, communication of research to technical and non-technical audiences, grant writing and mentoring students at the graduate and undergraduate level.

Research

I am interested in **pervasive sensing** and how technology can help digitize the **identity, location and status information** of physical assets such as products, fabrics, buildings etc. This information would help solve problems in resource optimization, particularly in the developing world. I focus on those applications for which data capture solutions either do not exist or else are inadequate. My work is **interdisciplinary** and incorporates elements such as electromagnetics, antenna design, signal processing and machine learning.
Some examples of projects that I have worked on include:

- Development of chipless RFID time-temperature sensors deployed on individual items in the cold chain.
- Development of a UHF RFID moisture sensor that can integrated into a diaper at low-cost. Our approach repurposed the diaper's hydrogel as an antenna for the sensor.
- Development of diagnostic algorithms that made use of dashboard mounted smartphone accelerometer and GPS data to detect structural issues in vehicles such as wheel imbalance and tire wear.

Teaching

- **Co-instructor, MIT 2.996 Basics of RFID and RFID-based sensing** Spring 2021-22
  Graduate level course that covers the basics of UHF RFID systems. Topics include technology history, understanding the physical layer, reader and tag design and the Gen 2 communication protocol.
- **Thesis Committee Co-Director, University of Navarra** Spring 2020-Present
  Serving as co-advisor for 2 PhD students at the University of Navarra, Spain.
- **Mentor, MIT Auto-ID Labs** June 2012 - Present
  I have mentored the following types of students:
  - 10 MIT graduate and 7 visiting graduate students. Interactions have culminated in the publication of 11 journal and 23 peer reviewed conference papers.
  - 4 undergraduate and 3 high-school students. The students obtained experience in different areas such as programming, manufacturing and product design, signal processing and wireless data acquisition.

- **Lectures in Professional Education** 2015-20
  Lectures in wireless sensor design for different IoT applications delivered at:
  - Mining Innovation in a New Environment (MINE); a joint MIT - Vale Mining Company, Cambridge MA, February 2020.
  - MIT IoT Bootcamp, Cambridge MA, May 2017.
  - IoT 360 Summer School, Rome, Italy, October 2015

Grants

- **Lead author** on annual *$580K* corporate research grants FY 2016-Present
  Research on wireless sensor development for cold chain, circular economy (recycling) applications.
- **Lead MIT author** on three *$15K* MISTI travel grants FY 2020-Present
  Grants facilitate travel between MIT researchers and collaborators at Tecnun Navarra and Universitat Oberta de Catalunya respectively.
- **Co-author with 1 other colleague** on *$200K* research grant proposal FY 2018-19
  Awarded by Exxon Mobil for the development of a chipless RFID tagging strategy to improve the efficiency of plastics recycling.
- **Co-author with 1 other colleague** on *$200K* research grant FY 2017-18
  Awarded by Compañía Manufacturera de Papeles y Cartones (CMPC) for the development of an RFID enhanced smart diaper for insult event monitoring.

Patents and Patent Applications

- **Applying Motion Sensor Data to Wheel Imbalance Detection, Tire Pressure Monitoring and/or Tread Depth Measurement**, *US Patent: 10,830,908*
  This patent presents an approach for using smartphone data to detect structural and functional issues with a vehicle's tires.
- **System and Method for Wireless Sensing of Health Monitoring**, *US Patent: 11,185,449, China Application No: 201980071672.2, Chile: 2021 - 000612*
  This patent presents an approach for designing passive RFID-based insult event detectors in diapers by making use of conductive hydrogels.
- **Wireless enabled surgical suture needle**, *US20210204936 A1*
  This patent application presents several methods to enhance surgical suture needles with RFID tags.

Honors and Awards

- *Winner of Best Paper Award*, IEEE Sensors Journal, July 2020
- *Winner of Best Student Paper Award*, 2019 IEEE International Conference on RFID-TA, Pisa, Italy, 2019.
- *Co-winner, as co-founder of Team GroundState, at MIT Water Innovation Prize*, MIT Water Innovation Prize Competition, MIT, 2016.
- *Winner of Best Paper Award*, 2015 IEEE International Conference on RFID-TA, Tokyo, Japan, 2015.

Professional Activities

- Executive Chair, IEEE International Conference on RFID, Cambridge MA 2024
- Associate Editor, IEEE Sensors Journal, September 2023 - Present
- Associate Editor, IEEE Journal of RFID, September 2018 - Present
- Technical Program Co-Chair, IEEE International Conference on RFID, Orlando FL 2020
- Technical Program Chair, IEEE International Conference on RFID, Orlando, FL 2018 and Phoenix, AZ 2019
- Invited PhD thesis committee member, Department of Electrical and Computer Engineering, Carnegie Mellon University, January 2019
- Co-Editor, IEEE TASE: Special Issue on "Advances and Applications of Internet of Things for Smart Automated Systems", August 2014 - June 2016
- Technical Program Co-Chair, 4th International Conference on the Internet of Things, Cambridge MA, October 6-8, 2014
- Workshop Chair, IEEE International Conference on RFID, Orlando FL, April 2013-16
  Coordinated the organization of workshops in near field and UHF RFID systems, NFC, bio-medical sensing, near metal applications and the potential of using the 5.8 GHz band for RFID.
- Technical Program Committee Member, IEEE International Conference on RFID, 2011-Present

Expert Reviewer

- Nature Communications
- IEEE Transactions on Automation Science and Engineering
- IEEE International Conference on RFID
- IEEE Internet of Things Journal
- IEEE Internet of Things Conference
- IEEE Transactions on Network and Service Management
- ASTM Journal of Testing and Evaluation
- Sensors and Actuators A: Physical Sensors Journal
- Journal of Medical Systems
- IEEE Sensors Journal

Selected Talks

- Panel member, "Workshop: What Should Gen3 Be?", 2020 IEEE International Conference on RFID, Online, October 2020.
- "Low-cost, pervasive sensing leveraging existing wireless infrastructure", invited lecture at Microsoft Research IoT Innovation Symposium, Seattle WA, July 2017.
- "Keeping TABS on blood disease: RFID Tag Antenna-Based Sensing for anemia detection", RFID Journal Live: 14th Annual Conference and Exhibition, Orlando, FL, May 2016.
- "Low-cost, pervasive sensing leveraging existing wireless infrastructure," Re.Work Internet of Things Summit, Boston, MA, May 2015.

- Panel Member, "The 'Cloud of Things' and Pervasive Computing," 4th Annual Auto-ID and Sensing Expo at MIT, June 13, 2013.
- "Enabling field intelligence with RFID tag antenna-based sensors," Auto-ID Labs update meeting, GS1 Standards Event, Dallas, TX, March 2013.
- "Towards Chipless RFID Tag Antenna-Based Sensing," Convened Session on Industrial, Environmental and BioMedical Sensing, IEEE RFID-TA 2012, Nice, France, November 2012.
- "Keeping TABS on Things: Field Intelligence using RFID Tag Antenna-Based Sensors," ISA Communications Division: Passive Wireless Sensing Technologies Workshop, La Jolla, CA, June 6-7, 2012.
- "UHF RFID Tag Antenna-Based Sensing," RFID and Sensing Workshop, IEEE RFID 2012, Orlando, FL, April 2012.

Consulting Experience

Founder, ConnectID Systems LLC, Chelmsford MA June 2017 - Present
I provide engineering and scientific consulting expertise to clients in cold chain, automotive, oil and gas and fashion. Work activities involve summarizing technical concepts in simpler terms, evaluating the pros and cons of different technologies, preparing and evaluating hardware prototypes and suggesting solutions to engineering problems.

News Articles

- Research on RFID-based sensing featured in MIT News, June 2018 and February 2020
- Research on low-cost, anemia sensing featured in news article, RFID Journal, December 2015.
- Research featured in news article on low-cost, vaccine freeze monitoring, RFID Journal, July 2015.
- Featured in news article on condition monitoring of infrastructure, RFID Journal, July 2013.

Publications

- JOURNAL PUBLICATIONS

1. F. Villa-Gonzalez, A. Rezola, D. del Rio, R. Bhattacharyya and D. Valderas, "SDR-based Monostatic Chipless RFID reader with Vector Background Subtraction Capabilities," in IEEE Transactions on Instrumentation and Measurement, Vol 72, pp. 1-14, 2023.
2. D. Valderas, F. Villa-Gonzalez, R. Bhattacharyya and S. Sarma, "Time-temperature excursion monitoring using chipless RFID tags and organic oils," in IEEE Sensors Journal, July 2023, doi: 10.1109/JSEN.2023.3297656.
3. D. Tellbach, F. Villa-Gonzalez, H. Li, R. Bhattacharyya and S. Sarma, "Wireless Material Identification in the Recycling Chain Using Chipless RFID Tags," in IEEE Sensors Journal, May 2023, doi: 10.1109/JSEN.2023.3279009.
4. F. V. Gonzalez, R. Bhattacharyya, T. Athauda, S. E. Sarma and N. C. Karmakar, "Detecting Breaks in Cold Chain Integrity Using Chipless RFID Time-Temperature Sensors," in IEEE Sensors Journal, vol. 22, no. 18, pp. 17808-17818, September 2022, doi: 10.1109/JSEN.2022.3194249.
5. J. L. Andrés, J. M. Seguí, R. Bhattacharyya, X. Vilajosana and S. E. Sarma, "Towards Low-cost RF-based Bulk Fabric Classification for the Textile Industry," in IEEE Sensors Journal, vol. 22, no. 16, pp. 16586-16594, 15 Aug.15, 2022, doi: 10.1109/JSEN.2022.3188936.
6. S. Dey, R. Bhattacharyya, S. E. Sarma and N. C. Karmakar, "A Novel 'Smart Skin' Sensor for Chipless RFID Based Structural Health Monitoring Applications," IEEE Internet of Things Journal, doi: 10.1109/JIOT.2020.3026729.
7. P. Sen, S. N. R. Kantareddy, R. Bhattacharyya, S. E. Sarma and J. E. Siegel, "Low-Cost Diaper Wetness Detection Using Hydrogel-Based RFID Tags," IEEE Sensors Journal, vol. 20, no. 6, pp. 3293-3302, March 2020.

8. S. N. R . Kantareddy, I. Mathews, S. Sun, M. Layurova, J. Thapa, J.P. Correa-Baena, R. Bhattacharyya, T. Buonassisi, S. Sarma, and I. M. Peters. "Perovskite PV-powered RFID: enabling low-cost self-powered IoT sensors.", IEEE Sensors Journal, Vol. 20, No.1, pp. 471-478, January 2020.
9. S. N. R. Kantareddy, I. Mathews, R. Bhattacharyya, I. M. Peters, T. Buonassisi and S. E. Sarma, "Long Range Battery-Less PV-Powered RFID Tag Sensors," IEEE Internet of Things Journal, Vol. 6, No. 4, pp. 6989-6996, August 2019.
10. J. Siegel, R. Bhattacharyya, S. Kumar and S. Sarma, "Air Filter Particulate Loading Detection using Smartphone Audio and Optimized Ensemble Classification", Engineering Applications of Artificial Intelligence, Vol. 66, pp 104-112, November 2017.
11. P. Kalansuriya, R. Bhattacharyya and S. Sarma. "RFID Tag Antenna-Based Sensing for Pervasive Surface Crack Detection," IEEE Sensors Journal, Vol. 13, No. 5, pp 1564-1570, May 2013.
12. R. Bhattacharyya, C. Floerkemeier and S. Sarma. "Low-Cost, Ubiquitous RFID-Tag Antenna Based Sensing," Proceedings of the IEEE - RFID: A Unique Radio Innovation for the 21^{st} Century, Vol. 98 No. 9, 2010, pp 1593-1600.

- REFEREED CONFERENCE PROCEEDINGS

1. P. García-Cardarelli, F. V. Gonzalez, M. Vinacua, J. Paredes-Puente, D. Valderas and R. Bhattacharyya, "Low-cost chipless RFID tag glucose sensor for diabetes screening", *accepted for presentation* 2023 IEEE Sensors Conference, Vienna, Austria, 2023.
2. D. Suo, H. Li, R. Bhattacharyya, J. M. Seguí and S. Sarma, "RF-enhanced Pavement Markings for Mobile Robot Lane Detection", *accepted for presentation*, 2023 IEEE International Conference on Automation Science and Engineering, Auckland, New Zealand, 2023.
3. D. Suo, R. Bhattacharyya, J. M. Seguí and S. Sarma, "RFID-enhanced Connected Lane Markings: Design Constraints and Requirements", 2023 IEEE Applied Sensing Conference (APSCON), Bengaluru, India, 2023, pp. 1-3, doi: 10.1109/APSCON56343.2023.10101139.
4. F. V. Gonzalez, R. Bhattacharyya and S. E. Sarma, "Single and bulk identification of plastics in the recycling chain using chipless rfid tags," 2021 IEEE International Conference on RFID, Atlanta, GA, 2021, pp. 1-8.
5. S. N. R. Kantareddy, Y. Sun, R. Bhattacharyya and S. E. Sarma, "Learning Gestures Using A Passive Data-Glove With RFID Tags," 2019 IEEE International Conference on RFID Technology and Applications (RFID-TA), Pisa, Italy, 2019, pp. 327-332.
6. T. Athauda, R. Bhattacharyya, N. Karmakar and S. Sarma, "Electromagnetic characterization of a food safe, organic smart material for customizable temperature threshold sensing in cold chain applications," 2019 IEEE International Conference on RFID (RFID), Phoenix, AZ, USA, 2019, pp. 1-6.
7. S. Dey, R. Bhattacharyya, N. Karmakar and S. Sarma, "A Folded Monopole Shaped Novel Soil Moisture and Salinity Sensor for Precision Agriculture Based Chipless RFID Applications," 2019 IEEE MTT-S International Microwave and RF Conference (IMARC), Mumbai, India, 2019, pp. 1-4.
8. Y. Sun, S. N. R. Kantareddy, R. Bhattacharyya and S. E. Sarma, "X-Vision: An Augmented Vision Tool with Real-Time Sensing Ability in Tagged Environments," 2018 IEEE International Conference on RFID Technology and Application (RFID-TA), Macau, 2018, pp. 1-6.
9. S. N. R. Kantareddy, R. Bhattacharyya and S. Sarma, "UHF RFID tag IC power mode switching for wireless sensing of resistive and electrochemical transduction modalities," 2018 IEEE International Conference on RFID (RFID), Orlando, FL, 2018, pp. 1-8.
10. S. N. R. Kantareddy, R. Bhattacharyya and S. E. Sarma, "Low-cost, automated inventory control of sharps in operating theaters using passive RFID tag-sensors," 2017 IEEE International Conference on RFID Technology and Application (RFID-TA), Warsaw, 2017, pp. 16-21.
11. S. N. R. Kantareddy, R. Bhattacharyya and S. Sarma, "Towards low-cost object tracking: Embedded RFID in golf balls using 3D printed masks," 2017 IEEE International Conference on RFID (RFID), Phoenix, AZ, 2017, pp. 137-143.
12. S. Dey, R. Bhattacharyya, N. Karmakar and S. Sarma, "Electromagnetic Characterization of Soil Moisture and Salinity for UHF RFID Applications in Precision Agriculture," *in* Proceedings of the 2016 IEEE sponsored EuMW Conference, *London, UK*, October 3-7, 2016.

13. J. Siegel, R. Bhattacharyya, A. Desphande, and S. Sarma, "Smartphone-based vehicular tire pressure and condition monitoring," *in* Proceedings of the 2016 IEEE sponsored SAI Intellisys Conference, *London, UK*, September 21-22, 2016.
14. E. Md Amin, R. Bhattacharyya, S. Sarma and N. Karmakar, "Microfluidic paper based Passive RF Sensor for Soil Salinity Measurement," *in* Proceedings of the 2016 IEEE MTT-S sponsored Australian Microwave Symposium, *Adelaide, Australia*, February 11-12, 2016.
15. J. Siegel, R. Bhattacharyya, A. Deshpande and S. Sarma, "Smartphone-Based Wheel Imbalance Detection," *in* Proceedings of the 2015 ASME Dynamic Systems and Controls Conference, *Columbus, OH*, October 28-31, 2015, pp V002T19A002; 10 pages.
16. A. Hasan, R. Bhattacharyya and S. Sarma. "Towards pervasive soil moisture sensing using RFID tag antenna-based sensors," *in* Proceedings of the 2015 IEEE RFID-TA Conference, *Tokyo, Japan*, September 16-18, 2015, pp 165-170.
17. R. Bhattacharyya, C. Swanson, M. Wong, B. Tien, E. Md Amin, I. Ehrenberg and S. Sarma, "Towards low-cost, wireless blood anomaly sensing: An RFID-based anemia detection sensor," *in* Proceedings of the 2015 IEEE International Conference on RFID, *San Diego, CA*, April 15-17, 2015, pp 189-196.
18. J. Siegel, R. Bhattacharyya, A. Deshpande and S. Sarma, "Vehicular Engine Oil Service Life Characterization Using On-Board Diagnostic (OBD) Sensor Data," *in* Proceedings of the 2014 IEEE Sensors Conference, *Valencia, Spain*, November 2-5, 2014, pp 1722-1725.
19. E. Md Amin, R. Bhattacharyya, S. Kumar and S. Sarma, "Towards low-cost, Resolution Optimized Passive UHF RFID Light Sensing," *in* Proceedings of the 2014 IEEE Wireless and Microwave Technology Conference, *Tampa, FL*, June 5-6 2014, pp 1-6.
20. E. Md Amin, R. Bhattacharyya, S. Sarma and N. Karmakar, "Chipless RFID Tag for Light Sensing," *in* Proceedings of the 2014 IEEE Antennas and Propagation Society International Symposium (APS URSI), *Memphis, TN*, July 6-11, 2014, pp 1308-1309.
21. P. Kalansuriya, R. Bhattacharyya and S. Sarma. "A novel communication method for semi-passive RFID based sensors," *in* Proceedings of the 2014 IEEE International Conference on Communications, *Sydney, Australia*, June 10-14, 2014, pp 5902-5907.
22. A. Hasan, R. Bhattacharyya and S. Sarma. "A Monopole-Coupled RFID Sensor For Pervasive Soil Moisture Monitoring," *in* Proceedings of the 2013 IEEE Antennas and Propagation Society International Symposium (APS URSI), *Orlando, FL*, July 7-13, 2013, pp 2309-2310.
23. R. Bhattacharyya, P. Kalansuriya and S. Sarma. "An antenna-based RFID expansion joint monitor," *in* Proceedings of the 2013 IEEE Antennas and Propagation Society International Symposium (APS URSI), *Orlando, FL*, July 7-13, 2013, pp 2305-2306.
24. P. Kalansuriya, R. Bhattacharyya, S. Sarma and N. Karmakar. "Towards Chipless RFID-Based Sensing for Pervasive Surface Crack Detection," *in* Proceedings of the 2012 IEEE RFID: Technologies and Applications Conference, *Nice, France*, November 2012, pp 46-51.
25. R. Bhattacharyya, D. Deavours, C. Floerkemeier and S. Sarma. "Tag Antenna Based Temperature Sensing in the Frequency Domain," *in* Proceedings of the 2011 IEEE International Conference on RFID, *Orlando, FL*, April 2011, pp 70-77.
26. R. Bhattacharyya, C.V Di Leo, C. Floerkemeier, S. Sarma and L. Anand. "RFID Tag Antenna Based Temperature Sensing using Shape Memory Polymer Actuation," *in* Proceedings of the 2010 IEEE Sensors Conference, *Waikoloa, HI*, November 2010, pp 2363-2368.
27. R. Bhattacharyya, C. Floerkemeier and S. Sarma. "Tag Antenna Based Temperature Sensing," *in* Proceedings of the 2010 IEEE International Conference on RFID, *Orlando, FL*, April 2010, pp 8-15.
28. R. Bhattacharyya, C. Floerkemeier and S. Sarma. "RFID Tag Antenna Based Sensing: Does your Beverage Glass need a Refill?," *in* Proceedings of the 2010 IEEE International Conference on RFID, *Orlando, FL*, April 2010, pp 126-133.
29. R. Bhattacharyya, C. Floerkemeier and S. Sarma. "Towards Tag Antenna Based Sensing - An RFID Displacement Sensor," *in* Proceedings of the 2009 IEEE International Conference on RFID, *Orlando FL*, April 2009, pp 95-102.