Nurani Saoda

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Summary

My research goal is to significantly improve the lifespan of extremely resource-constrained edge computers by enabling perpetual, sustainable, and pervasive sensing. To enable this vision, I design, develop, test, and deploy new hardware designs and software approaches that abstract the underlying energy-intermittency from application operation, achieve reliable, reusable, and scalable design points for both standalone and collaborative sensing applications in the Internet-of-Things (IoT) domain. Moreover, I explore techniques to design novel ways of non-invasive sensing with minimal design overhead that augment the functionalities of tiny energy-harvesters beyond a power source. By exploring, understanding, and developing these techniques, my research aims to push the boundaries for green and long-lived Internet-of-Things.

Education

University of Virginia Charlottesville, VA
PhD Candidate *in Computer Engineering* Aug 2017 – Dec 2022 (expected)
Dissertation: Energy-Intelligent Sensing Systems
Advisor: Dr. Bradford Campbell
Dissertation Committee: Dr. Jack Stankovic, Dr. Benton Calhoun, Dr. Steven Bowers, Dr. Josiah Hester, and Dr. Bradford Campbell

University of Virginia Charlottesville, VA
M.S. *in Computer Engineering* Aug 2017 – Aug 2020
Advisor: Dr. Bradford Campbell

Bangladesh University of Engineering and Technology (BUET) Dhaka, Bangladesh
B.S. *in Electrical and Electronic Engineering* Feb 2011 – Mar 2016
Thesis: Mutual Information-Based Selection of Audiovisual Affective Features to Predict Instantaneous Emotional State
Advisor: Dr. S M Mahbubur Rahman

Research Experience

Graduate Research Assistant Charlottesville, VA
University of Virginia, PhD advisor: Dr. Bradford Campbell Mar 2018 – Present
Research Topic: Energy-harvesting and battery-less systems, Low power design, Internet of Things

- Proposed an energy supervisor design architecture that disintegrates energy optimization and application logic for energy-harvesting applications.
- Designed and implemented an on-device duty-cycle adaptation algorithm using reinforcement learning technique to achieve energy-neutral operation in post-deployment unknown energy-harvesting conditions.
- Working on hardware-software co-design of a system architecture to ensure reliable and instantaneous event detection in low energy-harvesting conditions.
- Designed and developed a novel technique to encode arbitrary digital data through the battery terminals of an IoT device by replacing the battery with a programmable energy-harvesting power supply.
- Proposed a novel technique to identify smart home occupants by distinguishing their distinct instantaneous voltage patterns induced on a photovoltaic energy-harvester.

Graduate Research Assistant Charlottesville, VA
University of Virginia, PhD Rotation advisor: Dr. Haiying Shen Aug 2017 – Feb 2018
Research Topic: Distributed file systems, Hadoop Distributed File System (HDFS)

- Implemented an energy-aware file popularity based adaptive replication policy for HDFS to reduce energy and storage consumption in large scale clusters.
- Evaluated and compared the performance of the adapted HDFS in terms of file replication latency, file read latency, storage consumption on a 45-node cluster.

Undergraduate Researcher Dhaka, Bangladesh
Bangladesh University of Engineering and Technology (BUET) Jan 2015 – Mar 2016
Advisor: Dr. S M Mahbubur Rahman
Research Topic: Signal processing, Emotion recognition using audio-visual signals

- Studied the performance of different audio-visual signal features of video data to predict the emotional state from real-time video streams.

Publications (**Google Scholar**)

Conference Papers:

1. RetroIoT: Retrofitting Internet of Things Deployments by Hiding Data in Underused Data Channels
Nurani Saoda, Victor Ariel Leal Sobral, Ruchir Shah, Wenpeng Wang, Bradford Campbell
28th ACM Conference on Mobile Computing and Networking (**MobiCom'22**)
[CORE ranking-**A***, 18.4% acceptance rate]

2. SolarWalk: Smart Home Occupant Identification using Unobtrusive Indoor Photovoltaic Harvesters.
Nurani Saoda, Md Fazlay Rabbi Masum Billah, Victor Ariel Leal Sobral, Tushar Routh, Wenpeng Wang, Bradford Campbell
9th ACM Conference on Systems for Energy-Efficient Built Environments (**BuildSys'22**)
[CORE ranking-**A***, 32.4% acceptance rate]

3. An Energy Supervisor Architecture for Energy-Harvesting Applications
Nurani Saoda, Wenpeng Wang, Md Fazlay Rabbi Masum Billah, Bradford Campbell
21st ACM/IEEE Conference on Information Processing in Sensor Networks (**IPSN'22**)
[CORE ranking-**A***, 30.2% acceptance rate]

4. Low Cost Light Source Identification in Real World Settings
Tushar Routh, **Nurani Saoda**, Md Fazlay Rabbi Masum Billah, Bradford Campbell
19th IEEE Conference on Sensing, Communication, and Networking (**SECON'22**)
[CORE ranking-**B**, 26.1% acceptance rate]

5. BLE Can See: A Reinforcement Learning Approach for Radio Frequency based Occupancy Detection
Md Fazlay Rabbi Mashum Billah, **Nurani Saoda**, Jiechao Gao, Bradford Campbell
20th ACM/IEEE Conference on Information Processing in Sensor Networks (**IPSN'21**)
[CORE ranking-**A***, 24.8% acceptance rate]

6. UbiTrack: Enabling Scalable & Low-Cost Device Localization with Onboard WiFi
Wenpeng Wang, Zetian Liu, Jiechao Gao, **Nurani Saoda**, Bradford Campbell
8th ACM Conference on Systems for Energy-Efficient Built Environments (**BuildSys'21**)
[CORE ranking-**A**, 26.2% acceptance rate]

7. Mutual Information-Based Selection of Audiovisual Affective Features to Predict Instantaneous Emotional State
Sudipta Paul, **Nurani Saoda**, S M Mahbubur Rahman, Dimitrios Hatzinakos.
19th IEEE Conference on Computer and Information Technology (**ICCIT'16**)[**Best paper award**]

8. Scanning for Sensors: Fusing Computer Vision and BLE Advertisement Signal for Accurate Sensor Localization in AR View.
Md Fazlay Rabbi Masum Billah, Md Mofijul Islam, **Nurani Saoda**, Fateme Nikseresht, Tarique Iqbal, Bradford Campbell
22nd ACM Conference on Embedded Networked Sensor Systems (**IPSN'23**) [Submitted]

9. Looking through your screen: Real world Low Power Passive Sensing of On Screen Activities
Tushar Routh, **Nurani Saoda**, Md Fazlay Rabbi Masum Billah, Bradford Campbell
12th International Conference on Internet of Things (**ICCPS'23**) [Submitted]

10. WiFi Fine Time Measurement for Decimeter-level Localization on Single-Antenna Devices
Wenpeng Wang, Jiechao Gao, **Nurani Saoda**, Fateme Nikseresht, Viswajith Govinda Rajan, Bradford Campbell
22nd ACM Conference on Embedded Networked Sensor Systems (**IPSN'23**) [Submitted]

11. An Energy-harvesting System Architecture for Reliable Event Detection with Intermittent Power.
Nurani Saoda, Viswajith Govinda Rajan, Bradford Campbell [In preparation]

Workshop Papers and Posters:

1. SolarWalk Dataset: Occupant Identification using Indoor Photovoltaic Harvester Output Voltage
Nurani Saoda, Md Fazlay Rabbi Masum Billah, Victor Ariel Leal Sobral, Bradford Campbell
5th International SenSys/BuildSys Workshop on Data (**DATA'22** with **SenSys'22**)

2. Poster Abstract: Fusing Computer Vision and BLE Advertisement Signal for Accurate Sensor Localization in AR View.
Md Fazlay Rabbi Masum Billah, Md Mofijul Islam, **Nurani Saoda**, Fateme Nikseresht, Tarique Iqbal, Bradford Campbell
20th ACM Conference on Embedded Networked Sensor Systems (**SenSys'22**)

3. Developing a General Purpose Development Platform for Energy-harvesting Applications
Nurani Saoda, Md Fazlay Rabbi Masum Billah, Bradford Campbell
9th ACM Workshop on Energy Harvesting & Energy-Neutral Sensing Systems (**ENSsys'21** with **SenSys'21**)

4. No Batteries Needed: Providing Physical Context with Energy-Harvesting Beacons
Nurani Saoda, Bradford Campbell
7th ACM Workshop on Energy Harvesting & Energy-Neutral Sensing Systems (**ENSsys'19** with **SenSys'19**)

5. Low Power but High Energy: The Looming Costs of Billions of Smart Devices
Wenpeng Wang, Victor Ariel Leal Sobral, Md Fazlay Rabbi Masum Billah, **Nurani Saoda**, Nabeel Nasir, Bradford Campbell
1st ACM Workshop on Sustainable Computer Systems Design and Implementation (**HotCarbon'22** with **OSDI'22**)

Selected Research Projects

Altair: An energy supervisor architecture for energy-harvesting applications

- Proposed and designed a new energy-harvesting power management architecture, Altair, that offloads all energy-management operations to the power supply itself, while making the power supply programmable. The proposed design achieves modularity, flexibility, and better energy optimization for battery-less designs.
- Proposed and developed an on-device duty cycle adaptation technique using reinforcement learning to ensure optimal energy utilization and device performance in post-deployment conditions.
- Microcontrollers: STM32L010R8, nRF52840, Tools: EAGLE CAD, GNU ARM Embedded toolchain, Language: Embedded C, Node.js
- Funding: National Science Foundation (NSF) (link), Strategic Investment Fund at the University of Virginia (link)

RetroIoT: Retrofitting existing IoT devices with new functionality

- Proposed and demonstrated a technique that uses the reported battery voltage channel of an IoT sensor to inject additional data such as an advanced sensor, metadata or tag and retrofit the device with advanced functionality.
- Implemented a digital data encoding technique by replacing the device's battery with a programmable energy-harvesting power supply.
- Development platforms used: STM32L0 LoraWan kit, Tools: EAGLE CAD, Language: Embedded C, Python
- Funding: National Science Foundation (NSF) (link, link), Strategic Investment Fund at the University of Virginia (link)

SolarWalk: Occupant identification using small photovoltaic harvesters

- Proposed a new non-invasive, unobtrusive, and infrastructure-free method to identify occupants in smart home from their distinguished solar cell output voltage traces using machine learning techniques.
- Development platforms used: Nordic nRF52840 DK, Language: Embedded C, Python

Herald: Investigating the performance of intermittently-powered solar beacons

- Analyzed the performance of intermittently-powered solar energy-harvesting Bluetooth Low Energy (BLE) beacons in different indoor lighting conditions by designing a low power solar beacon.
- Evaluated the viability of solar-powered beacons in low indoor light conditions and identified crucial design-level and system-level factors while using intermittently powered beacons.
- Microcontrollers: nRF51822, Tools: EAGLE CAD, Language: Embedded C, Python
- Funding: National Science Foundation (NSF) (link), Strategic Investment Fund at the University of Virginia (link)

Awards and Scholarships

- **Link Lab Student Seminar Award** 2022
  University of Virginia 2022
- **ACM SIGBED SRC Winner**, Second Runner-up 2022
  ACM SIGBED SRC 2022
- **Travel Grant Award** 2022
  ACM MobiCom 2022
- **Finalist of NCWIT Collegiate Award** 2022
  National Center for Women & Information Technology (NCWIT)
- **Student Scholar** 2019, 2021
  Grace Hopper Celebration
- **CRA-WP Grad Cohort** 2020
  Computing Research Association-Widening Participation
- **N2Women Young Researcher Fellowship** 2019
  17th ACM Conference on Embedded Networked Sensor Systems (SenSys'19)
- **CRA-E Funding Award** to attend CRA-E workshop on Academic Careers, FCRC'19 2019
  Computing Research Association Education
- **Travel Grant** for Society of Women Engineers (SWE'18) conference 2018
  School of Science and Engineering, University of Virginia
- **Best Paper Award** 2016
  19th IEEE Conference on Computer and Information Technology (ICCIT'16)
- **PhD Fellowship** Aug 2017–Jul 2018
  Department of Computer Engineering, University of Virginia
- **Eugene McDermott Graduate Fellowship Award** 2017
  Four-year fellowship to conduct independent research in the Joint Biomedical Engineering Program of UTSW and UT Dallas. (not availed)
- **Achievement Award Scholarship** 2017
  Herbert Wertheim College of Engineering, University of Florida. (not availed)
- **Dean's List Award** 2012
  Bangladesh University of Engineering & Technology (BUET)
- **Talent Scholarship in 8th, 10th, and 12th grade Nationwide Exams** 2006 – 2015
  National Education Board, Government of Bangladesh

Conference Presentations

1. SolarWalk: Smart Home Occupant Identification using Unobtrusive Indoor Photovoltaic Harvesters
   9th ACM Conference on Systems for Energy-Efficient Built Environments (**BuildSys'22**)

2. RetroIoT: Retrofitting Internet of Things Deployments by Hiding Data in Battery Readings
   28th ACM Conference on Mobile Computing and Networking (**MobiCom'22**)

3. An Energy Supervisor Architecture for Energy-Harvesting Applications
   21st ACM/IEEE Conference on Information Processing in Sensor Networks (**IPSN'22**)

4. Developing a General Purpose Development Platform for Energy-harvesting Applications
   9th ACM Workshop on Energy Harvesting & Energy-Neutral Sensing Systems (**ENSsys'21**)

5. No Batteries Needed: Providing Physical Context with Energy-Harvesting Beacons
   7th ACM Workshop on Energy Harvesting & Energy-Neutral Sensing Systems (**ENSsys'19**)

6. Mutual Information-Based Selection of Audiovisual Affective Features to Predict Instantaneous Emotional State
   19th IEEE Conference on Computer and Information Technology (**ICCIT'16**)

Talks and Posters

1. Presented my research on *Broadening the Capabilities of Self-Powered Energy-Harvesting Systems*
   UVA Link Lab Student Seminar Award Series Nov 2022

2. Altair: An Energy Supervisor Architecture for Energy-Harvesting Applications
   ACM SIGBED SRC at Embedded Sytems Week (ESWEEK'22) Oct 2022

3. 3-Minute Thesis: Making *Energy-intelligent* devices for Internet-of-Things
   13th ACM (S3'22) Workshop at **MobiCom'22** Oct 2022

4. Presented poster: Occupancy Sensing in the Smart Environment: Problems, Progress, & Potential
   Computer Science Research Symposium, University of Virginia Oct 2022

5. Submitted Poster: *Enabling Energy-harvesting Internet-of-Things*
   Computer Science Research Symposium, University of Virginia Dec 2021

6. Presented Poster: *A platform to Enable Battery-less Sensing*
   Engineering Research Symposium, University of Virginia [poster] Apr 2021

7. Invited talk on *Making IoT Batteryless: Challenges and Opportunities*
   Embedded Systems Lunch Meetings, University of California, San Diego Jan 2021

8. Link Lab Student Flash Talk, University of Virginia Dec 2020

9. Presented Poster: *Platforms for Doing More with Increasingly Limited Edge Devices*
   Computer Science Research Symposium, University of Virginia [poster] Feb 2019

Teaching Experience

Graduate Teaching Assistant Charlottesville, VA
University of Virginia Jan 2019 – May 2020
Courses: Computer Networks (Spring 2019), Discrete Mathematics (Spring 2020)

- Held weekly office hours for assignments and exams, led in-class discussions, helped the instructor prepare term questions, and grading exams.

Lecturer, EEE Dhaka, Bangladesh
Uttara University May 2016 – Jun 2017

- Designed course layout, prepared and delivered lectures, held weekly office hours, prepared and graded exams.
- Conducted laboratory classes with lectures and hands-on demonstration to students.

- Provided academic support as student advisor and supervised undergraduate student research projects.
- Courses: Electric Properties of Materials, Energy Conversion-I and II, Fundamentals of Electrical Engineering, Renewable Energy
- Labs: Microprocessor and Interfacing, Communication Theory Lab, Energy Conversion-I and II, Computer Programming, Electric Services Design, Electric Circuits Lab, Control Systems Lab

Student Mentoring Experience

- Vishwajith Govinda Rajan, Computer Engineering Masters student, University of Virginia 2022
- Jyoti Kumari, Computer Engineering Masters student, University of Virginia
  Current position: Software Engineer at Qualtrics 2019
- Alexander Sarris, Computer Engineering Masters student, University of Virginia
  Current position: Electrical Engineer at Northrop Grumman 2018
- Jessica Xu, Computer Science Undergrad student, University of Virginia
  Current position: Software Engineer at Reddit 2018

Academic Service and Leadership Experience

- **TPC Member and Reviewer** 2022
  13th ACM Wireless of the Students, by the Students, and for the Students Workshop (S3'22)
- **Reviewer of Birds of a Feather Session** 2022
  ACM Special Interest Group on Computer Science Education Technical Symposium (SIGCSE TS'23)
- **Organizer and Host** 2019
  Networking Networking Women (N2Women) Meeting in conjunction with ACM SenSys'19
- **Publicity Chair and Department Representative** Aug 2021 – Jul 2022
  Graduate SWE at University of Virginia
- **Media Chair** Aug 2019 – Jul 2020
  Association of Bangladeshi Students at University of Virginia
- **Recruitment Coordinator** 2018
  IEEE Smart Village
- **Organizing Committee Member and Program Host** 2016, 2017
  New undergraduate student orientation program, Uttara University

Volunteer Experience

Summer Outreach Program Volunteer Aug 2022
Helped organize a five day *Build The Internet* summer camp for 6th-12th graders
C4K, Charlottesville
Graduate Student Mentor Aug 2021 – Dec 2021
Department of Computer Science, University of Virginia
Research and Analysis Volunteer Aug 2019 – Jul 2020
SWE Student Programs Workgroup, Society of Women Engineers (SWE)
Mentoring Circles Committee Member 2019
Grace Hopper Celebration
Career Fair Recruitment Volunteer Oct 2018
Recruit prospective students for UVA engineering at Society of Women Engineers (SWE) national convention career fair

News Coverage

- **"Long-Lived Things for the Internet of Things"**, University of Virginia School of Science and Engineering and EurekaAlert (2022)
- Recognized in The National Center for Women & Information Technology (NCWIT) press release for the contribution of the project Altair (2022)

Technical Skills

- **Programming Language**: Python, C/C++/C#, Embedded C, MATLAB, Verilog, Java, Javascript (Node.js), ARM Assembly Language
- **Microcontrollers**: nRF52840, nRF52832, nRF51822, STM31L010R8, MSP430FR6989
- **Hardware Platforms**: Nordic nRF52840 DK, Thingy:52, STM32NUCLEO-L010RB, STM32L0 LoraWan Kit
- **Real-time OS**: Zephyr RTOS
- **Embedded Development IDE**: Keil uVision, STM32CubeIDE, SEGGER Embedded Studio, TI Code Composer Studio
- **Electric Circuit Analysis and Simulation**: Cadence, PSpice, Xillinx Vivado, Orcad, Quartus II, PSAF
- **Electronic Design Automation**: EAGLE, Proteus
- **Numerical Analysis**: MATLAB

Academic Membership

Graduate student member, ACM and ACM-W	2017 – present
Graduate student member, ACM SIGMOBILE and ACM SIGCOMM	2018 – present
Graduate student member, IEEE, IEEE WIE, IEEE Computer Society, IEEE Young Professionals.	2017 – present
Graduate collegiate member, SWE	2017 – present