Sumaiya Shomaji

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Research Interest

Application of machine learning, image processing, computer vision, and blockchain to solve emerging challenges in biometrics, hardware security, internet of things, and healthcare.

Teaching Interest

Fundamentals of Biometric authentication, Fundamentals of machine learning, Image processing and computer vision, Design and Analysis of Algorithms, Introduction to Data Structures, Introduction to Deep learning, Programming Language (Python), Basics of machine learning with Python, Introduction to Hardware Security, Digital Logic Design, DC Circuits etc.

Education

University of Florida, Gainesville, FL **August 2021**
Doctor of Philosophy (Ph.D.) in Electrical and Computer Engineering
Advisor: Dr. Domenic Forte, Co-advisor: Dr. Swarup Bhunia
CGPA: 3.86/4.00

University of Florida, Gainesville, FL **May 2021**
Master of Science (M.S.) in Electrical and Computer Engineering
Advisor: Dr. Domenic Forte, Co-advisor: Dr. Swarup Bhunia
CGPA: 3.86/4.00

Ahsanullah University of Science and Technology (AUST), Dhaka, Bangladesh **June 2013**
Bachelor of Science (B.Sc.) in Electrical and Electronic Engineering
CGPA: 3.92/4.00 (Merit position 5th among 170+ graduating students)

Ph.D. Dissertation

Title: Efficient authentication and tracking of human and hardware
Committee: Dr. Domenic Forte (chair), Dr. Swarup Bhunia (co-chair), Dr. Damon Woodard, and Dr. Natalie Christina Ebner

Summary: Due to the proliferation of IoT devices in numerous human interactive applications, there is a significant need for low-cost access control schemes that allow humans (i.e., connected people) to use IoT systems in a secure and efficient manner. Traditional biometric access control systems remain, however, vulnerable to physical attacks resulting in template theft, illegal access, etc. On the other hand, ensuring the integrity and security of hardware devices has become challenging due to the globalization of the semiconductor industry, requiring robust tracking of hardware throughout its lifetime. The existing approaches for both human access control or hardware tracking suffer from large storage requirements and latency in query handling. Therefore, there is a need for authentication/tracking techniques that require less storage, offer fast processing of query, and protect privacy of the users. In this work, a three-step solution has been proposed as the one-stop solution of the discussed problems, namely: (i) privacy-preserving signature generation, (ii) storage of the signatures, and (iii) communication of the signatures. Firstly, a secure signature generator is designed using Binarized Convolutional Neural Network (BinCNN) which extracts the prominent features from human/hardware. While CNNs provide promising performance for generating prominent features, their exhaustive training process and requirement of large no. of samples, make them unsuitable for resource constrained IoT devices. Therefore, BinCNN, a modified CNN, is proposed that produces binary templates which are faster to process and suitable for IoT applications. Secondly, a hierarchical Bloom Filter (HBF) based data structure is proposed to store the signatures that provides privacy, space-efficiency, rapid query handling and noise tolerance. The two discussed steps along with some image processing techniques in the biometric signatures make a secure and efficient human access control system. However, for hardware, a third step is required to verify their integrity in the supply chain. Therefore, the secure and efficient signature-based tracking is combined with blockchain to thwart counterfeiting of hardware.

Research / Work Experience

University of Florida, Gainesville, FL **Aug 2016 to Aug 2021**

Research Assistant

Summary: Application of various machine algorithms, image processing techniques, and data structures for designing secure and efficient human and device authentication systems and wearable healthcare devices. Produced six accepted publications, one provisional patent, and one funded proposal.

Funded/ non-funded projects served: **Visit this link for details on the projects**

- A machine learning based compact and distinctive features extraction system (**Army Research Office**)
- Efficient and secure large-scale biometric Systems (**Army Research Office**)
- Human-to-device (H2D) authentication framework (**Army Research Office**)
- A deep learning-based model for analysing similarity in biometric properties among kin people for preventing presentation attack (**Army Research Office**)
- Blockchain-based supply chain framework for tracking electronics (**Nimbis Services**)
- Detecting harmful dyes from vegetables by low field NMR relaxometry and machine learning based model
- Wearable carotid ultrasound assembly for early detection of cardiovascular diseases
- Secure signature generation from nano-electro-mechanical tags for product authentication (**Discover Financial Services**)

Stamford University Bangladesh **Jan 2014 to Aug 2015**

Lecturer

Taught several courses including Biomedical Electronics, Electrical Circuits (theory and lab), and Digital Electronics (theory and lab). More details are included under the teaching experience section.

Awards and Honors

- **Best Poster Award (1st prize among 71):** Warren B. Nelms Annual IoT Conference 2019.
- **Best Oral Presentation Award (1st prize):** UF's Diversity Graduate Research Symposium 2019.
- **People's Choice Award (Among 40 participants):** Three Minute Thesis (3MT) competition 2019 at University of Florida.
- **Honorary Mention Award in Poster Presentation (Among 32 participants):** Workshop for Women in Hardware and Systems Security (WISE) in IEEE Int. Symposium on Hardware Oriented Security and Trust (HOST) conference, 2019.
- **Best Poster Award:** Workshop for Women in Hardware and Systems Security (WISE) in IEEE International Symposium on Hardware Oriented Security and Trust (HOST) conference, 2017.
- **Panelist at WISE 2019:** Participated as a panelist in student panel on "Our Voice in Hardware and Systems Security" in Women in Hardware and Systems Security (WISE) workshop in IEEE International Symposium on Hardware Oriented Security and Trust (HOST) conference, 2019.
- **Women and Girls in Science Recognition Awards 2019**: ECE department, UF.
- **NSF Travel Grant** to attend Conference on Cryptographic Hardware and Embedded Systems (CHES), 2019.
- **NSF Travel Grant** to attend IEEE International Symposium on Hardware Oriented Security and Trust, 2017, 2018, and 2019.
- **Research Assistantship:** Granted by department of ECE, University of Florida.
- **Tuition Scholarship:** Granted based on the academic performance in each semester by Ahsanullah University of Science and Technology.
- **Dean's Merit Award:** Granted based on academic performance in the undergraduate program by Ahsanullah University of Science and Technology.

Teaching Experience

University of Florida, Gainesville, FL

- Teaching Assistant in Dept. of ECE: Fundamentals of Biometric Identification, Spring 2020. **Visit this link to watch one of my lectures during the course.**
- Teaching Assistant in Dept. of ECE: Fundamentals of Biometric Identification, Spring 2018.

Duties performed: preparing lecture slides, delivering lectures, designing homework assignments and questions for exam, holding student hours, invigilating during exams, and grading exam copies and assignments.

Topics covered during lectures: traditional biometric authentication systems, popular biometric modalities, application of machine learning algorithms (PCA, LDA, CNN etc.) for biometric classification tasks, image processing techniques for biometric template preprocessing (face detection, image alignment, image normalization, mugshot image generation), probability theory, score matching techniques in biometric authentication systems, and biometric template protection schemes (hashing, encoding, etc.).

Stamford University, Dhaka, Bangladesh

- Lecturer in Dept. of Electrical and Electronic Engineering: Biomedical electronics, Electrical circuits (theory and lab) and Digital electronics (theory and lab), Jan 2014 to August 2015.

  Duties performed: preparing lecture slides, delivering lectures, designing homework assignments and questions for exam, holding student hours, invigilating during exams, grading exam copies and assignments, student counseling for higher education and research, preparing class schedules for faculties, and arranging career development seminar and workshops.

  Topics covered during lectures: introduction to existing biomedical electronics infrastructure, associated design challenges, future of biomedical electronics, security and privacy in biomedical sector, introduction to the basic concepts of DC circuits, combinational circuits, sequential circuits, finite state machines.

Journal Publications

Journal Papers Accepted:

1. **S. Shomaji,** P. Ghosh, F. Ganji, D. Woodard, and D. Forte, *"*An Analysis of Enrollment and Query Attacks on Hierarchical Bloom Filter-based Biometric Systems", to appear in *IEEE Transactions on Information Forensics and Security (TIFS),* 2021.
2. **S. Shomaji,** Z. Guo, F. Ganji, N. Karimian, D. Woodard, and D. Forte, *"*BLOcKeR: A Biometric Locking Paradigm for IoT and the Connected Person", in *Journal of Hardware and Systems Security* (*HaSS),* pp.1-14, 2021.
3. **S. Shomaji,** N. Masna, D. Ariando, S. Paul, K. Horrace, D. Forte, S. Mandal, and S. Bhunia, "Detecting Dye-Contaminated Vegetables Using Low-Field NMR Relaxometry", in *Foods*, 10(9), p.2232, 2021.
4. R. Tabrizian, S. Rassay, M. Ramezani**, S. Shomaji,** and S. Bhunia, "Clandestine Nano-Electro-Mechanical Tags for Identification and Authentication", in *Microsystems & Nanoengineering, Nature,* 2020.
5. **S. Shomaji**, P. Dehghanzadeh, A. Roman, D. Forte, S. Bhunia, S. Mandal, "Early Detection of Cardiovascular Diseases Using Wearable Ultrasound Device", in *IEEE Consumer Electronics Magazine* 8.6 pp(12-21), 2019.

Conference Publications

Conference Papers Accepted:

1. **S. Shomaji**, F. Ganji, D. Woodard, and D. Forte, "Hierarchical Bloom Filter Framework for Security, Space-efficiency, and Rapid Query Handling in Biometric Systems", in *IEEE 10th International Conference on Biometrics Theory, Applications and Systems (BTAS) (pp. 1-8)*, 2019.
2. **S. Shomaji**, A. Basak, R. Karam, S. Mandal, S. Bhunia, "A Wearable Carotid Ultrasound Assembly for Early Detection of Cardiovascular Diseases", in *IEEE-NIH Special Topics Conference on Healthcare Innovations and Point-of-Care Technologies (HI-POCT)*, 2016.
3. **S. Shomaji**, A. Basak, S. Mandal, S. Bhunia, "A Wearable Carotid Ultrasound Assembly for Early Detection of Cardiovascular Diseases", in *38th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC),* 2016.
4. S. Gupta, **S. Shomaji**, F. Islam, T. Hasan, and Z. Ahmed, "Performance Analysis of DS-CDMA Wireless Communication System with & without Diversity", in *IEEE International Conference on Computer & Information Technology*, (2014).

Conference Papers Under Review/ To be Submitted:

1. **S. Shomaji**, M. Hasan, T. Hoque, F. Ganji, D. Woodard, and D. Forte, "A Resource-efficient, Binary CNN Implementation for Contactless IoT Authentication in the Post-COVID World", to be submitted in *IEEE International Symposium on Hardware Oriented Security and Trust (HOST),* 2022.
2. P. Ghosh, **S. Shomaji**, D. Woodard, and D. Forte, "Kin-Wolf: Face Presentation Attack Using Kinship-established Wolfs", to be submitted in *International Conference on Biometrics Theory, Applications and Systems (BTAS),* 2022.

Patents and Copyrights

- D. Forte, **S. Shomaji**, D. Woodard, F. Ganji, "BLOcKeR: A Biometric Locking Paradigm for IoT and the Connected Person ", UF Patent reference no. T18320US001, submitted Sep. 17, 2020.

Technical Skills

Programming Language:

- More than four years of experience in Python:
  - Scikit Learn (machine learning library containing wide range of supervised and unsupervised learning algorithms)
  - Dlib (library for machine learning algorithms)
  - OpenCV (library for computer vision and machine learning applications)
  - TensorFlow and Keras (library for building Deep Neural Network)
  - Matplotlib, Plotly (library for data visualization)
  - SciPy (library for mathematical functions)

- NumPy (library for array-processing packages)
- Pandas (library for data structures and data analysis tools)

- Familiar with MATLAB, C, C++.

Softwares: Weka (machine learning tool), Pix2Net (Layout to gate extraction tool), ImageJ (image processing), Microsoft Office, Microsoft Visio, LaTeX.
Hardware & Instruments: NIR and NMR spectroscopy machine, Ultrasound imagining device, DVM6 Microscope (optical imaging), 8086 and 8085 Microprocessor, Oscilloscope, Digital/Analog Trainer Boards.

Oral Presentations

- "Hierarchical Bloom Filter Framework for Security, Space-efficiency, and Rapid Query Handling in Biometric Systems", in *IEEE International Conference on Biometrics: Theory, Applications and Systems (BTAS)*, 2019.
- "Secure and Efficient Storage of Large-Scale Biometric Data", in *UF's Diversity Graduate Research Symposium*, 2019.
- "Secure and Efficient Storage of Large-Scale Biometric Data", in *Three Minute Thesis (3MT) Competition* at University of Florida, 2019.

Poster Presentations

- "Efficient and Secure Large-Scale Biometric Systems", in *Warren B. Nelms Annual IoT Conference*, 2019.
- "Hierarchical Bloom Filter Framework for Security, Space-efficiency, and Rapid Query Handling in Biometric Systems", in *IEEE International Conference on Biometrics: Theory, Applications and Systems (BTAS)*, 2019.
- "Secure and Efficient Big Data Management for Biometrics", in *Women in Hardware and Systems Security (WISE) Workshop in IEEE International Symposium on Hardware Oriented Security and Trust (HOST) Conference, 2019*.
- "A Wearable Carotid Ultrasound Assembly for Health Care and Biometric Security", in UF's Diversity Graduate Research Symposium, 2019.
- "Secure and Efficient Big Data Management for Integrated Circuits (ICs)", in *Women in Hardware and Systems Security (WISE) Workshop in IEEE International Symposium on Hardware Oriented Security and Trust (HOST) Conference, 2018*.
- "Secure and Efficient Big Data Management for Integrated Circuits (ICs)*",* in *FICS Annual Conf. on Cybersecurity,* 2017.
- "Early Detection of Cardiovascular Diseases Using Wearable Ultrasound Device", in *Women in Hardware and Systems Security (WISE) Workshop in IEEE International Symposium on Hardware Oriented Security and Trust (HOST) Conference, 2017*.
- "Early Detection of Cardiovascular Diseases Using Wearable Ultrasound Device", in *FICS Annual Conf. on Cybersecurity,* 2017.
- "A Wearable Carotid Ultrasound Assembly for Early Detection of Cardiovascular Diseases", in *IEEE Engineering in Medicine and Biology Society (EMBC), 2016.*

Proposal Writing Experience

- Collaborative Research: IUSE: EHR: AI Education for All through Coherent Integration of Foundational Concepts into Core Courses, submitted to Improving Undergraduate STEM Education: Education and Human Resources (IUSE: EHR), NSF in July 2021 (Rejected), Amount Requested for TTU: $200,000.
  Contribution: Submitted the proposal as PI.
- SWIFT: A Signature-enabled Wireless Infrastructure for Forensic Tracking, and Locking of Electronic Systems, funded by Army Research Office (ARO).
  Contribution: As a PhD student, wrote the draft for the primary investigator (my PhD supervisor) describing the proposed machine learning based signature generation tool for human and electronics.

Review Activities

- IEEE Transactions on Biometrics, Behavior, and Identity Science (TBIOM)
- IEEE Internet of Things Journal (IoT-J)
- IEEE Transactions on Multi-Scale Computing System (TMSCS)
- International Conference on Security, Privacy and Applied Cryptographic Engineering (SPACE)
- Sensors journal by MDPI

Mentorship Experience

I have mentored two graduate and two undergraduate students:

- Steffi Roy, *graduate student at the University of Florida* — Spring 2021 to Present
- Pallabi Ghosh, *graduate student at the University of Florida* — Spring 2020 to Present
- Luke A Rouleau, *undergraduate student at the University of Florida* — Spring 2019
- Kelsey Horrace, *undergraduate intern from Jackson State University* — Summer 2019

Extra-curricular Activities

- Worked as a volunteer at IEEE International Symposium on Hardware Oriented Security and Trust (HOST), 2017/18/19 and FICS Annual Conference on Cybersecurity, 2017 and 2018.
- Student participant at iREDEFINE workshop by 2020 ECEDHA Annual Conference.
- Teacher at the Gainesville Bangla School where kids can learn the Bengali language for free.

Collaborators

- Prof. Damon Woodard, Ph.D., University of Florida, Gainesville, FL, USA
- Prof. Swarup Bhuniya, Ph.D., University of Florida, Gainesville, FL, USA
- Prof. Soumyajit Mandal, Ph.D., University of Florida, Gainesville, FL, USA
- Prof. Roozbeh Tabrizian, Ph.D., University of Florida, Gainesville, FL, USA
- Prof. Fatemeh Ganji, Ph.D., Worcester Polytechnique Institute, Worcester, Massachusetts, USA
- Prof. Robert Karam, Ph.D., University of South Florida, Tampa, FL, USA
- Prof. Nima Karimian, Ph.D., San Jose State University, San Jose, California, USA

Leadership Experience

- Serving as social media chair of "CyberGatorz", a student-based organization
  Duties: Maintaining the CyberGatorz Facebook page to promote the activities of the student members.

Professional Memberships

- Student Member, IEEE

References

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**Additional references available upon request.*