Saif Ur Rahman

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Research Interests

Physics-grounded machine learning for wireless systems; neural fields and neural operators; differentiable simulation; RF propagation and sensing; wireless digital twins.

Education

University of Illinois Urbana-Champaign **Jan 2023 – May 2028 (expected)**
Ph.D. in Computer Science; GPA: 3.79/4.00; Advisor: Prof. Elahé Soltanaghai *Champaign, IL*

- **Relevant Coursework:** Machine Learning for Signals, Advanced Wireless Networks & IoT, Advanced Computer Networks, Deep Generative Models, Mobile Computing & Applications.

Lahore University of Management Sciences (LUMS) **Sep 2018 – May 2022**
B.S. in Electrical Engineering, Minor in Computer Science; GPA: 3.98/4.00 *Lahore, Pakistan*

- **Relevant Coursework:** Digital Signal Processing, Distributed Systems, Information Theory & Machine Learning.

Research Experience

Graduate Research Assistant, iSens Lab **Jan 2023 – Present**
University of Illinois Urbana-Champaign; Advisor: Prof. Elahé Soltanaghai *Champaign, IL*

WiNeRF: Measurement-Constrained Neural Fields for Wireless Channel Modeling
EWSN 2026 · First Author · PDF

- Developed **WiNeRF**, a physics-grounded neural field that learns continuous complex-valued wireless channels from sparse commodity WiFi CSI, using hardware-imposed angular resolution and phase uncertainty as inductive constraints.
- Designed and implemented the end-to-end **PyTorch** architecture using cone-based wave sampling, multi-resolution hash grids, and differentiable CSI reconstruction; built a **C++/ROS/Nexmon-CSI** robotic data pipeline and collected ∼30K synchronized CSI and pose measurements across three indoor environments.
- Achieved **5.30 dB median channel-prediction SNR**, outperforming prior neural baselines by **3.0–6.7 dB**, while preserving channel structure for beamforming, MUSIC AoA estimation, and coverage mapping; achieved beamforming within **0.6 dB of oracle CSI**.

PU-HNO: Physics-Unrolled Neural Operator for Wireless Field Modeling
Submitted to NeurIPS 2026 · arXiv PDF

- Contributed to **PU-HNO**, a multi-fidelity neural operator that learns high-fidelity radio maps from low-cost ray tracing and noisy simulation labels, using scene geometry and materials as physical priors.
- Developed propagation-aware model components that progressively refine **reflection, diffraction, and scattering** structure; generated multi-fidelity **Sionna RT** datasets for training and evaluation.
- Achieved **3.47 dB RMSE** and **0.82 outage F1**; radio maps used for AP placement yielded **92 Mbps vs. 16 Mbps** with a CNN baseline on a 10,000 m^2 floorplan.

CanopyTwin: Physics-Grounded Vegetation Modeling for Wireless Digital Twins
Ongoing Research · Neural Operators · Wireless Digital Twins

- Addressing a key fidelity bottleneck in **wireless digital twins**: practical ray tracers simplify vegetation through penetration loss, effective materials, or approximate scattering, while explicitly resolving leaf- and branch-level interactions is prohibitively expensive at scene scale.
- Designing a **physics-grounded neural operator** to learn the aggregate RF scattering behavior of vegetation from high-fidelity simulation, replacing expensive internal geometry with a compact learned representation.
- Developing the physical abstraction and learning formulation for **complex multi-interaction scattering**, with the goal of enabling fast, differentiable, vegetation-aware propagation modeling at scene scale.

WiViz: Interactive Visualizations for Wireless Literacy
Ongoing Research · HCI + Wireless Systems

- Designing **3D mechanism-revealing visualizations** to help non-experts understand multipath, contextual performance, and interference.
- Leading the current **user-study design and evaluation**, comparing heatmaps, static rays, and animated signals; contributing to the **Unity/Sionna RT** implementation.
- In a prior **24-participant study**, improved mechanism correctness from **24.2% to 80.6%** and decision accuracy from **65.2% to 87.5%** over heatmaps.

Publications

- **Saif Ur Rahman**, Rafid Umayer Murshed, Anton Dmitriev, Cagri Tanriover, Rahul C. Shah, Elahé Soltanaghai. "**WiNeRF: Measurement Constrained Radiance Fields for Actionable Wireless Channel Modeling**." *EWSN 2026.* **First author.** [PDF]

- Rafid Umayer Murshed, **Saif Ur Rahman**, Mingyue Tang, Elahé Soltanaghai. "**Physics-Unrolled Neural Operator for Wireless Field Modeling**." *Submitted to NeurIPS 2026*; arXiv:2608.18495. **Second author.** [arXiv] [PDF]

Technical Skills

Programming: Python, C++, MATLAB, Go, C#, Bash, Assembly
Machine Learning: PyTorch, TensorFlow, Keras, scikit-learn; neural fields, neural operators, multi-fidelity learning, differentiable rendering
Scientific Computing: NumPy, SciPy, pandas, CUDA
Computer Vision: OpenCV
Wireless & Signal Processing: WiFi CSI, MIMO, OFDM, RF sensing, channel modeling, multipath, beamforming, MUSIC/AoA
Simulation & Robotics: NVIDIA Sionna RT, Wireless InSite, ROS, Nexmon CSI, ORB-SLAM3, Proteus
Systems & DevTools: Linux, Git, Docker, CMake, SSH, TCP/UDP sockets, LaTeX
Hardware & XR: USRP, ADALM-PLUTO, Impinj RFID, TI mmWave radar, iRobot Create 3, Intel RealSense, Unity, Meta Quest

Earlier Research Experience

Research Assistant, Centre for Urban Informatics, Technology & Policy **Aug 2022 – Nov 2022**
Lahore University of Management Sciences; Advisor: Prof. Momin Uppal *Lahore, Pakistan*

- Developed a **BERT**-based topic and sentiment analysis pipeline over **∼500K tweets** for a **$1.5M World Bank-funded** urban-policy project and built an interactive dashboard for stakeholder analysis.

Undergraduate Research Assistant, Smart Data Systems & Applications Lab **Jan 2021 – May 2022**
Lahore University of Management Sciences; Advisors: Prof. Muhammad Tahir and Prof. Momin Uppal *Lahore, Pakistan*

- **RFID Respiration Sensing:** Developed a passive **UHF RFID** sensing pipeline using multi-tag phase measurements, signal processing, and a stacked **LSTM** to estimate breathing rate during body motion, with a respiration belt providing synchronized ground truth.
- **WiSM:** Developed a contactless soil-moisture sensing system using **NI USRP-2921 SDRs** and WiFi-like OFDM, relating RF reflection loss to soil permittivity and moisture through **Topp's Equation** and validating the prototype in indoor and outdoor experiments.

Selected Software & Systems

- **Raft-Based Key-Value Store (Go):** Built a fault-tolerant replicated key-value store and implemented the Raft consensus protocol for replication across multiple servers.

Honors & Awards

- **Qualcomm Innovation Fellowship Finalist, North America**, 2025 — *Neural Fields for Indoor Wireless Propagation Simulation & Modeling*
- **Ray Ozzie Computer Science Fellowship**, UIUC, 2023–2024
- **National Management Foundation Gold Medal**, LUMS, 2022 — top of Electrical Engineering class
- **Dean's Honor List**, LUMS, 2019, 2020, 2021, 2022

Teaching Experience

- **CS 225: Data Structures**, UIUC — Teaching Assistant, Fall 2025 & Spring 2026
- **EE 514 / CS 535: Machine Learning**, LUMS — Teaching Assistant, Spring 2022
- **EE 310: Signals and Systems**, LUMS — Teaching Assistant, Spring 2021
- **MATH 230: Probability**, LUMS — Teaching Assistant, Spring 2020