




Muhammad Ahmed Mohsin Research Internship (Statement of Purpose)




[Cadet College Hasanabdal \(CCH\)](#). I felt pride for the first time when I secured admission into CCH. I was among the top 80 students selected from a pool of thousands of applicants to study at this prestigious institution. CCH gave me profound exposure and instilled ambition in me to strive for excellence in all my endeavors, and that is what I have been aspiring to do ever since. It gave me a headstart that has helped me profusely throughout. In my intermediate examinations, I achieved 3rd position in FBISE board in a pool of more than 100,000 candidates and, in recognition, received a medal from the President of Pakistan. Moreover, my ECAT (Engineering entrance test) score placed me in the top 10 students among thousands of applicants nationwide. I continued to strive for excellence in NUST (acceptance rate less than 1%) and held my position in the top 3% students of the batch.


I started to incline more toward pursuing research as a vocation in academia when I observed the professional lives of my supervisors, Dr. Faisal Shafait and Dr. Adnan ul-Hassan. They had completed graduate studies in Germany and worked at prestigious organizations such as Google. They talked me on how good research advances human knowledge and drives innovation. For example, their research in tabular information extraction could be deployed at a large-scale level to automate data entry in National Identity cards. This single endeavor has the capacity to significantly optimize time efficiency for numerous individuals. Understanding their motivation behind cutting-edge research and the impact they intend to create from it inspired me to pursue research wholeheartedly. ‘What if I could be a part of something larger that contributes to society?’ Research was more than just a path to knowledge; it was a means to convey what I find interesting and important.

Research Experiences

During my undergraduate studies, I built a deep foundation in research methodologies. These experiences have aptly primed me to pursue research internship at KAUST. I was privileged to engage in research during my freshman year internship at the TUKL R&D lab. Collaborating with accomplished professors, Dr. Faisal Shafait  and Dr. Adnan ul-Hassan , I delved into deep learning in tabular augmentation. My interest drove me to explore various deep-learning architectures, their usage, and their backbone algorithms. By the end of summer, I independently developed a more accurate model network for the novel *TabAug* (Tabular Augmentation) technique. My proposed method showcased superior efficacy compared to conventional augmentation techniques because it followed multidimensional augmentation of rows and columns of tabular images. My results were presented at the annual meeting of chairs at TUKL R&D research laboratory and were well-appreciated.

In sophomore year, collaborating with a partner, we proposed a novel deep-learning technique for table detection. Through an exhaustive literature review and rigorous model evaluations and implementations, we presented a Transformer-based Table Recognition in Image-based documents. This model introduced a tabular image generative augmentation technique employing clustering, fusion, and patching phases. Our approach demonstrated superior model performance across all datasets, surpassing contemporary state-of-the-art models, including Microsoft’s DiT. This was accepted at **ICDAR 2023**  conference in California.

In my junior year, I took my time to settle for a research domain that involved Deep learning and Electrical engineering. I was driven by my interest in next-generation wireless networks (6G), cultivated during my computer and communication networks elective taught by Dr. Hassan Khaliq . His assignments regarding modern research in wireless networks and their advanced algorithms helped me transition to wireless networks. To further enhance my interest in communication systems, I participated in **Huawei ICT Competition**, Network Track, and managed to be among the National Finalists from Pakistan. This further enhanced my interest and background in wireless networks. Currently, I am awaiting results for the Regional Finals qualification (Asia region). From here, I developed engagement in interdisciplinary research in wireless networks and machine learning. During summer’23, under the supervision of Dr. Syed Ali Hassan , my focus centered on STAR-RIS-enhanced NOMA-CoMP networks. We proposed a novel system model and used heuristic allocation strategies to optimize downlink rates. This work was accepted at **IEEE Globecom 2023**¹  as co-first author. Furthermore, we documented our work as an open-source wireless simulator library in python **SimComm: Cellular Network Simulator**², containing the essential elements of 6G such as NOMA, CoMP, RIS, multiple fading channels and analytical functions as well, such as moment matching, meijer g and Nakagami-*m* fading.

After my initial research in 6G networks, I started the in-depth statistical analysis of our system model. To evaluate the performance of our proposed system model, we formulated probability density functions (PDFs) of our signal-to-interference-plus-noise ratio (SINR) functions. Further, using Gamma approximations to model the Nakagami-*m* fading channels based on the method of moments (MoM) and the central limit theorem (CLT), we derived closed-form expressions for the ergodic rates and outage probabilities at each node of our system. Our analytical and simulated results overlapped, demonstrating the accuracy of our analytical approach. This work is submitted to **IEEE Communication Letters**  as a co-first author.

Currently, I am working on designing and implementing a dynamic resource allocation scheme for maximizing sum rates in wireless networks using deep reinforcement learning (DRL). Due to the high dimensionality and non-convex nature of the resource allocation problem, heuristic mathematical approaches fall short of optimal solutions. We are developing a DRL-based resource allocation scheme, considering the stochastic nature of the wireless

¹ All papers accepted in 2023, with conferences awaiting their imminent convening.

² GitHub link to [SimComm: Cellular Network Simulator](#) 

environment, and plan to present a journal publication at IEEE Vehicular Transactions for this ongoing work. I have undertaken diverse projects to augment my expertise in communication theory and networks. Notably, I've explored resource allocation through reinforcement learning for control systems, delved into NOMA and OFDMA networks for communication systems, and am currently engaged in Vision-Transformer Enabled Communication Compression – a machine learning approach employing autoencoders to optimize wireless system efficiency.

As I continued my research at the IPT lab, I was nominated by my university for an internship opportunity with Dr. Omair Shafiq from Information Technology Department (IT), Carleton University, Canada. This opportunity served as a conduit for honing my skills in generative AI while concurrently augmenting my understanding of reinforcement learning, which would help me in my ongoing project. In this capacity, I directed my research efforts toward Zero-shot learning (ZSL) algorithms executed through generative adversarial networks (GANs). My results extended to a comparative assessment between Self-Attention GANs (SAGANs) and conventional GANs, an idea proposed independently, unveiling SAGANs marked performance superiority due to fewer model collapses and attention layer mechanisms. This work was accepted at 20th **International Conference on Frontiers of Information Technology IEEE 2023**, as a first author.

Meanwhile, I developed an urge to use my deep learning knowledge in industry-based projects to interlink my theoretical knowledge to the practical deployment of our models. I independently engaged myself in a project, fault detection, and localization in a hybrid digital twin for an induction motor using AI. We took real-time data and modeled synthetic faults in COMSOL, performed feature fusion using Canonical Correlation Analysis (CCA) to merge the datasets to create a hybrid twin, and then performed machine-learning classification to detect faults. We achieved higher accuracies and proved that hybrid twins work better than data-driven modeling. Our research paper was accepted in **IEEE Big Data 2023**, as co-first author. This work gave me a unique insight into the practical deployment of machine learning models in real-world applications.

These skills will be instrumental in optimizing wireless networks, resource allocation, and security because they involve real-time ML deployment. My research journey has instilled the confidence and motivation to continue exploring the boundaries and pursuing different research domains.

Attending KAUST

For my internship, I aspire to research in machine learning integrated in wireless communications. Due to my interdisciplinary approach, my focus converges on advancing mMIMO systems, Deep learning schemes for resource allocation for 5G Networks, beam forming and power allocation through deep learning and joint optimization for resource allocation through reinforcement learning algorithms. It is vital to allow generalization for a broader base and later refine the focus. I intend to create an impact through my research, leading to advancements in wireless networks. Dr. Ahmed Eltawil is working on this project and his papers on Sensing and Communication in UAV Cellular Networks: Design and Optimization [1], Explainable and Robust Artificial Intelligence for Trustworthy Resource Management in 6G Networks [2] and Machine learning based channel estimation method for frequency-selective mimo system are of my interest.

References

- [1] C. Diaz-Vilor, M. A. Almasi, A. M. Abdelhady, A. Celik, A. M. Eltawil, and H. Jafarkhani, "Sensing and communication in uav cellular networks: Design and optimization," *IEEE Transactions on Wireless Communications*, pp. 1–1, 2023. DOI: [10.1109/TWC.2023.3326457](https://doi.org/10.1109/TWC.2023.3326457).
- [2] N. Khan, S. Coleri, A. Abdallah, A. Celik, and A. M. Eltawil, "Explainable and robust artificial intelligence for trustworthy resource management in 6g networks," *IEEE Communications Magazine*, pp. 1–7, 2023. DOI: [10.1109/MCOM.001.2300172](https://doi.org/10.1109/MCOM.001.2300172).