Maaz Salman

Researcher, BU Laboratory

Education

2020–2024 **PhD Artificial Intelligence Convergence**, *Pukyong National University, Korea*, Busan, *3.92/4.5*.

A thesis investigating the application of wireless optical communication technologies for the advancement of Machine Learning-augmented Underwater Internet of Things. The thesis focused on exploring the possibility of using error correcting code in underwater optical communication (UWOC), developing and evaluating the performance of a multi-hop underwater wireless sensor network (UWSN), designing a prototype that utilizes relay-based diversity gain to enhance UWOC, and using data from IMU sensors to monitor the movement of aquaculture and predict the acceleration state of the target body using machine learning models. The research was conducted under the supervision of Prof. Wan-Young Chung. I have delivered presentations at two international conferences, two domestic conferences, a poster, and the findings from these presentations and research have been published in four SCIE IEEE journals.

Courses included:

- Big Data System
- Advanced Artificial Intelligence
- Body Sensor Network
- Advanced Data Science
- Wireless Communication

2018–2020 **Master Electrical Communication System Engineering**, *Soonchunhyang University, Korea*, Asan, *4.36/4.5*.

I performed research on the design and simulation of passive communication modules in the radio frequency and microwave spectrum, including amplifiers, power dividers, and antennas. The research was carried out under the supervision of Prof. Dal Ahn. I have attended an international conference, and the results of my research have been published in SCIE journal and conference.

Courses included:

- Electromagnetic Wave Theory
- Microwave Filter Design I and II
- Satellite Communication
- Wireless Communication System Design

2013–2017 **B.Sc. Telecommunication & Information System Engineering**, *University of Engineering and Technology*, Taxila, *3.12/4*.

Specialized in Wireless networks and communication systems.

Courses included:

- Object Oriented Programming
- Microprocessor & Interfacing
- Embedded Systems
- Digital Communication

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PhD thesis

Title *Wireless Optical Communication Technologies for Machine Learning-augmented Underwater Internet of Things*

Supervisor Prof. Wan-Young Chung

Description Internet of Things (IoT) devices and protocols connect smart devices in safe and risky environments to acquire or share information. Recent years have seen efforts to connect undersea devices known as the Internet of Underwater Things. To be effective, IoUT requires high information integrity, fast data transfer rates, and energy efficiency. We propose underwater wireless communication for in-situ environmental monitoring. Underwater wireless communication (UWOC) has advantages for underwater local area sensor networks (UWSN) than other technologies due to its high bandwidth, low cost, and reliable communication, compared to acoustic, RF, and high latency. The thesis commenced by developing and evaluating a low-power UWOC communication module with error-correcting code to address turbulence and small suspended particles which hinder the communication channel. The next challenge was to create a relay-based SIMO UWOC system for monitoring underwater environments. Depending on the communication channel, this system's clever algorithm switched between majority logic, selection, and equal gain combining. A multi-hop UWOC system is then built and tested for local area network underwater sensor networks. The system has several nodes to cover more area. Each sensor node comprises several sensors and a UWOC module. A resource-optimizing LAN-UWSN encoding method is proposed and evaluated. The project concluded with a UWOC-equipped underwater sensor module for fish monitoring. Inertial moment unit sensor (IMU) measures fish moment attributes and sends them to diversity gain enabled relay. Machine learning models, LSTM and GRU machine learning models were trained using IMU data to predict fish acceleration status.

Master thesis

Title *Modified Wilkinson Power Dividers by incorporation of supplementary Transmission Lines and Defected Ground Structure*

Supervisor Prof. Dal Ahn

Description Conventional Wilkinson Power Divider (WPD) is comprised of a pair of quarter wave transmission lines having equal impedances and an isolation resistor between them which facilitates it to generate an equally divided power at the output ports and better isolation between them. This thesis focuses on different structures of modified WPD by changing the topology and adding extra transmission lines in order to achieve novel designs and preferable outputs. The Defected Ground Structure (DGS) technology has been incorporated with these modified WPDs to obtain the required or better isolation loss and return loss. The simulated results have been compared with other notable similar works to evaluate the proposed circuit designs. Good agreement has been achieved between simulated results and measured results. Moreover, due to the embed of DGS with the modified WPD, in some cases, improved isolation and return loss have been obtained as compared with the contemporary similar works.

B.Sc. thesis

Title *Review of Viable 5G Wireless communication Networks' Architectures, Key Technologies and Challenges*

Supervisor Lect. Lubna Nadeem

Description This project is focused on the evaluation, applications and review of previous cellular networks (1G to 4G LTE Advance) and leading to 5G. Several works related to 5G network have been dissected and analyzed to shed the light on the future development regarding researches on 5G and provide a basic lookout for a beginner 5G enthusiastics. Key technologies and methods such as Massive MIMO, Spatial Modulation, Distributed Antenna System, MIMO-OFDM and Millimeter Wave have been discussed, which can play a vital role in the 5G network.

Experience

Academia

2024–present **Researcher**, *BU Laboratory*, Busan, Korea.

By harnessing the power of artificial intelligence in conjunction with ultrasound signals, the BU laboratory is pioneering a revolution in cell, particle, and bio-material analysis. Through the development of sophisticated AI algorithms capable of rapid, automated, and precise cell characterization from ultrasound data, the laboratory aims to streamline disease diagnosis, drug development, and biotechnology research.

Responsibilities include:

- Application of Artificial Intelligence to Analyze Ultrasound Signals: Leveraging AI to discern patterns, parameters, and characteristic features within ultrasound signal data.
- CNN-Based Models and Machine Vision for Bio-material Analysis: Employing Convolutional Neural Networks and machine vision techniques for the analysis of bio-materials.
- Development of TinyML-Augmented Non-Invasive Ultrasound Modules: Creating compact, energy-efficient ultrasound modules enhanced with Tiny Machine Learning for non-invasive analysis.
- Publication of Peer-Reviewed Research: Disseminating research findings through publications in peer-reviewed scientific journals.

2020–2024 **Researcher**, *AIoT Laboratory*, Busan, Korea.

The Ph.D. degree in Artificial Intelligence Convergence from Pukyong National University, Korea involve research in areas include AI assisted IoT, UIoT, Underwater Wireless Sensor Network (UWSN), Underwater Optical Wireless Communication (UWOC).

Responsibilities include:

- Design and analysis of UWOC systems
- Prototype design of communication modules
- Development of ML augmented underwater Internet of things
- Publication of peer-reviewed research papers

2018–2020 **Research Assistant**, *RAMREC Laboratory*, Asan, Korea.

Worked related to the design and application of passive components at radio and microwave frequencies, DGS circuit applications, and circuit modeling using a commercial EM analysis program.

Responsibilities include:

- Design and evaluation of passive components at radio and microwave frequencies
- DGS circuit applications for radio modules
- Modeling and simulation of RF components using commercial EM analysis software
- Publication of peer-reviewed research papers

Industry

Sept. 2017– Dec. 2017 **Site Engineer**, *Special Communication Organization (SCO)*, G.B, Pakistan.
Responsibilities include:
- Site maintenance and installation
- Survey for 3G/4G BS sites

June. 2015– July. 2015 **Trainee Network Engineer**, *PTCL NSS Department*, Islamabad, Pakistan.
Responsibilities include:
- Training of UMG, MSC, and BSC maintenance and installation
- Operational procedure of new 3G/4G BS platforms
- Deployment of FTH networks

Languages

English 75 %

Urdu 70 %

Hangul 10 %

Balti 95 %

Skills & Tools

Python

Data Science

C++

AVR Studio

Arduino

DesignSpark

Stm32

HFSS

Matlab

R Studio

PyCharm

Multisim

Office

LaTex

Proteus

Packet Tracer

Raspbherry Pi

Network Analyzer

Antenna RPA

3D Printing

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Awards

August 2024 **Proud Foreign Student Award**, *Pukyong National University*, Busan, Korea.
The award was bestowed in recognition of the author's research work in the fields of Machine Learning, Internet of things, Internet of Underwater Things, Underwater Wireless Optical Communication, Visible Light Communication, and application of artificial intelligence in IoT platforms as well as participation in reputable and respected international and domestic conferences, and the publication of high-quality SCI journal articles that have been underwent to peer review process.

November 2021 **Best Excellent Paper Award**, *The Korea Institute of Convergence Signal Processing*, Busan, Korea.
We investigated the software implementation of the BCH (31,16) error correcting code for a noisy underwater wireless communication link. The encoding and decoding modules have been developed on a compact microcontroller unit (ATMEGA128A) to support applications on small mobile platforms.

Dec. 2023 **Excellent Paper Award**, *The KICSP Conference*, Jeju, Korea.
Experimental findings confirm that BER is highly affected by variations in parameters such as distance and intensity of light in UWOC. Using different machine learning (ML) models, namely Long Short-Term Memory (LSTM) and Multilayer Perceptron (MLP), the system's performance is estimated in terms of optimal and degrading performance. Notably, the LSTM model achieved an impressive accuracy rate of approximately 98.89% in detecting the system's performance when applied to an untrained dataset.

May 2024 **Proud Laboratory Award**, *The Brain Korea 21 (BK21)*, Korea.
The esteemed individuals of the AIoT Laboratory have been honored with the prestigious Proud Lab Award, bestowed upon them by the prestigious research project BK21 program for publishing quality peer-reviewed original research articles. The amount of prize money won was approximately 4 million Korean won.

Dec. 2021 **2021 FIRE Grant (BK21 Project)**, *The Brain Korea 21 (BK21)*, Korea.
The FIRE Grant Program is a reward for graduate students thesis performance to inspire graduate students research motivation and advance their research skills Program. The prize has been awarded for publishing a good JCR ranked journal paper.

June 2024 **2024 FIRE Grant (BK21 Project)**, *The Brain Korea 21 (BK21)*, Korea.
The prize money of 1.5 million won has been awarded by BK21 for publishing a top 10% JCR ranked IEEE journal paper.

Sept. 2020 **Brain Korea 21 (BK21)**, *National Research Foundation Korea (NRF)*, Korea.
To increase the research capacity of the core academic field and to nurture the subsequent generation of studies, BK21 is the steping stone. The fellowship has been awarded to graduate students who participate in ground breaking research in the field of science and other fields.

Publications

[1] Javad Bolboli, Maaz Salman, Ramavath Prasad Naik, and Wan-Young Chung. Experimental and simulation study of a lorawan-assisted relay for iout communication. *IEEE Transactions on Green Communications and Networking*, 2023.

[2] Youna Jang, Maaz Salman, Young Chae Jeong, Kwan Sun Choi, Sang-Min Han, and Dal Ahn. Wideband phase shifter using 3 types of lc resonant circuits for phase slope alignment. In *2019 PhotonIcs & Electromagnetics Research Symposium-Spring (PIERS-Spring)*, pages 4034–4039. IEEE, 2019.

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[3] R. P. Naik W-Y Chung JJ. Kim Maaz Salman, J. Balboli. Aqua-aware: Underwater optical wireless communication enabled compact sensor node, temperature and pressure monitoring for small mobile platforms. *KCISP Journal*, 23(2):50–61, 2022.

[4] Ramavath Prasad Naik, Maaz Salman, Javad Bolboli, Savidhan Shetty, and Wan-Young Chung. Multiuser data transmission aided by simultaneous transmit and reflect reconfigurable intelligent surface in underwater wireless optical communications. *IEEE Transactions on Vehicular Technology*, 2024.

[5] Ramavath Prasad Naik, Maaz Salman. Underwater optical image data transmission in the presence of turbulence and attenuation. *Journal of the Institute of Convergence Signal Processing. The Korea Institute of Convergence Signal Processing (KICSP)*, 24(no. 1):1–14, 2023.

[6] Maaz Salman, Javad Balboli, Ramavath Prasad Naik, et al. Aqua-aware: Underwater optical wirelesss communication enabled compact sensor node, temperature and pressure monitoring for small moblie platforms. , 23(2):50–61, 2022.

[7] Maaz Salman, Javad Bolboli, and Wan-Young Chung. Experimental demonstration and evaluation of bch-coded uwoc link for power-efficient underwater sensor nodes. *IEEE Access*, 10:72211–72226, 2022.

[8] Maaz Salman, Javad Bolboli, and Wan-Young Chung. A robust uwoc-assisted multi-hop topology for underwater sensor network nodes. In *International Conference on Convergence Signal Processing Technology 2023*. https://arxiv.org/abs/2403.19180, 2022.

[9] Maaz Salman, Javad Bolboli, Ramavath Prasad Naik, and Wan-Young Chung. Aqua-sense: Relay-based underwater optical wireless communication for iout monitoring. *IEEE Open Journal of the Communications Society*, 5:1358–1375, 2024.

[10] Maaz Salman, Javad Bolboli, Prasad Naik Ramavath, and Wan Young Chung. A multi-hop resource efficient uwoc-link assisted local area network for uiot monitoring. 2023.

[11] Maaz Salman and Wan-Young Chung. A resource efficient encoding algorithm for underwater wireless optical communication link. In *International Conference on Intelligent Human Computer Interaction*, pages 262–272. Springer Nature Switzerland Cham, 2023.

[12] Maaz Salman, Youna Jang, Jongsik Lim, Dal Ahn, and Sang-Min Han. Novel wilkinson power divider with an isolation resistor on a defected ground structure with improved isolation. *Applied Sciences*, 11(9):4148, 2021.

Recent Publications

- [13] Machine learning-assisted Movement Monitoring aided with UWOC for IoUT, IEEE INTERNET OF THINGS JOURNAL
- [14] Design and Performance Evaluation of a Relay-Assisted Hybrid LoRa/OpticalWireless Communication System for IoUT, IEEE Open Journal of the Communications Society

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- [15] Image-based VLC Signal Demodulation and Data Augmentation Using Machine Learning, IEEE Communication Letters
- [16] Wireless Optical Communication Technologies for Machine Learning-augmented Underwater Internet of Things, Ph.D. Thesis

Under review

- A Multi-hop Resource Efficient UWOC-Link assisted Local Area Network for UIoT Monitoring, Journal of Lightwave Technology
- Hybrid VLC/RF System for IoT with Augmented Embedded ML-based Link Switching, IEEE Transactions on Wireless Communications
- Development of Ultrasound-Based Driver Alcohol Detection System for Safety (UDADSS), IEEE Transactions on Intelligent Transportation Systems
- Tooth aging monitoring system based on secondary dentin analysis using ultrasound and artificial intelligence, Computers in Biology and Medicine
- AI-Augmented Ultrasound Analysis of Bio-material Concentration in Bio-printing, Computers in Biology and Medicine

References

Supervisors

- Prof. Wan Young Chung
- Prof. Dal Ahn
- Lect. Lubna Nadeem

Collaborators

- Dr. RP Naik, and
- Javad Bolboli

More

Dr. MAS Sejan, and **Dr. Lionel Nkenyereye** (all available upon request).

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