ECE657: Deep Learning Application

<u>Project Topic</u>: Deep Learning-Based Denoising of QAM-Modulated Audio Signals: Enhancing Communication Clarity Through Neural Networks

<u>Presenter</u>: *Luis Serge Olivier Geralda Tutab*

ABSTRACT

In modern digital communication systems, Quadrature Amplitude Modulation (QAM) is a popular choice for its efficient use of bandwidth. However, QAM signals are highly susceptible to noise, which can significantly degrade the quality of transmitted audio signals. This project explores the application of deep learning techniques, specifically Convolutional Neural Networks (CNNs), to denoise QAM-modulated audio signals, thereby improving the clarity of communications. The process is demonstrated through a comprehensive pipeline involving data acquisition, QAM modulation, noise introduction, neural network-based denoising, and error evaluation.

The project begins with data acquisition using the Windows Voice Recorder app to capture high-quality audio signals, and generating synthetic audio data using a random data set. These audio signals are then resampled, segmented, and modulated using 16-QAM. To simulate real-world conditions, Additive White Gaussian Noise (AWGN) is added to the modulated signals, creating a noisy dataset. A CNN is then trained to denoise these noisy QAM-modulated signals, with the training data comprising randomly generated audio signals and real-world recordings. The model's performance is evaluated using accuracy metrics and a confusion matrix, which are computed by comparing the bit sequences of the denoised and original signals.

For demonstration purposes, the project includes three key stages: playing the original audio, playing the noisy audio with impairments, and playing the denoised audio after it has been processed by the neural network. This showcase not only illustrates the effectiveness of the deep learning model in removing noise but also highlights the potential of such techniques in enhancing the robustness and clarity of communication systems.

This project demonstrates the practical application of deep learning in denoising QAM-modulated signals, providing valuable insights into improving communication systems'

robustness and clarity. The three-part demonstration effectively showcases the problem, the impact of noise, and the solution offered by the neural network model.