Abstract

Automatic Modulation Classification (AMC) is used to identify the modulation format of the received RF signal without any prior knowledge of the transmitted signal. It is an intermediate step of signal interception and demodulation. AMC has become a prominent area of research in the current scenario due to its use in many military and civilian applications. In the military, modulation identification is used in signal information extraction, jamming signal generation, and radio surveillance. In the civil domain, one of the important applications is adaptive modulation, which enables us to get optimum data rate and reliable communication by deciding the transmitting modulation according to the channel condition provided by the receiver for reliable communication. AMC is also being used for spectrum sensing. The exclusive frequency spectrum allocation to any user for the prevention of frequency intervention causes scarcity of frequency spectrum. This problem is being resolved by detecting frequency utilization in a particular band of spectrum and providing a balance between deficit and under-utilization. It is a basic building block for designing cognitive radios (CR) and software-defined radios (SDR). CR is employed for the identification of an unused frequency spectrum and provides it to other users for different time intervals.

In this research work, a method for modulation classification based on the constellation graphical representation is developed. Carrier frequency, symbol rate, and phase offset are the essential parameters that are estimated to extract the constellation points. An efficient way of classification between ASK, PSK, and QAM is proposed. ASK is differentiated from PSK and QAM using linear regression, and further classification between PSK and QAM is done using circle fitting. In further research section, some other methods for modulation classification using deep learning (DL) are developed. DL is a newly addressed area of research in the field of modulation classification. One of the methods for modulation classification based on the Symmetric Dot Pattern (SDP) representation of RF signal is developed. Snowflake images generated by the SDP technique are used to train the Deep Convolution Neural Network (DCNN). Two DCNN models viz. ResNet-50 and Inception ResNet V2, both concatenated by 8 fully connected layers are used for modulation classification. The density of points in the SDP pattern is used to create a grayscale image and RGB components are generated using Adaptive Local Power Law Transform (ALPLT), for color image formation. A hierarchical model of eight stages with each stage doing a binary classification using DCNN is formed.

Thesis also includes constellation density matrix (CDM) based modulation classification algorithm to identify different orders of ASK, PSK, and QAM. CDM is formed through the local density distribution of the signal constellation for a wide range of SNR. Two DL models, ResNet-50 and Inception ResNet V2 are trained through color images formed by filtering the CDM. In other work, the two-dimensional Fast Fourier Transform (2D-FFT) of constellation structure is used as a classification feature. CDM is formed using the density spread of constellation points and a 2D-FFT matrix is generated through the two-dimensional Fast Fourier Transform of CDM. A light and efficient DCNN model is designed to classify the modulation schemes of different orders of PSK and QAM.

The thesis work also includes a software-defined radio (SDR) based automatic modulation classification. A LabVIEW-based Field Programmable Gate Array (FPGA) implementation of a modulation classification algorithm is proposed. Any modulation scheme among BPSK, QPSK, 8PSK, 8QAM, 16QAM, and 4ASK is classified by alteration of oversampling factor and further error minimization between the extracted constellation and ideal constellation of considered modulation

schemes. The developed algorithm is implemented on NI-FlexRIO-7975 FPGA module with NI-5791 adapter and signals for testing are generated using NI-PXIe-5673.

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