Abstract

Blind Signal Modulation Recognition (BSMR) detects the type of modulation in the intercepted signal. BSMR is an intermediate step between signal detection and its demodulation. It is becoming an active research area due to its application in many military scenarios like surveillance and electronic warfare, which requires a type of modulation in intercepted signals to prepare jamming signals. BSMR gained more attention in cognitive radio (CR) as it is widely used for civilian applications like spectrum management, link adaptation to overcome from the problem of spectrum under-utilization. Most of the approaches for modulation classification are based on the modulated signal's component, but the modulation type can be best identified with the use of the constellation diagram. Modulations with well-defined constellation structure viz. ASK, PSK, and QAM are considered for classification.

BSMR involves two steps: first is preprocessing of the received signal in which different parameters are estimated like carrier frequency, symbol rate, channel state information, timing, and waveform recovery, etc., and the second step is the algorithm to classify the modulation format.

In this research, the constellation signature from the blind signal is extracted in different channel scenarios. As the constellation points form clusters in the I-Q plane, different clustering algorithms have been adopted for modulation classification between ASK, PSK, and QAM modulation schemes. Noisy data points corresponding to the same symbols are considered as a single cluster. The order of modulation can be obtained by estimating the correct number of clusters. This is done using the Density-based Ordering Points To Investigate the Clustering Structure (*OPTICS*) clustering algorithm. For modulation domain estimation, i.e., ASK, PSK, or QAM, k-means clustering and linear regression techniques are employed. In other work, different numbers of cluster centers are estimated using k-medoids clustering. A similarity function for calculating resemblance with ideal constellation structure is defined. It gives a decision in favor of the highest similarity score. The work is further extended to classify the FSK modulation scheme. A hierarchical and local density (HLD) approach is proposed to classify modulation schemes in a two-stage process. Local densities are calculated around the ideal points and compared for final modulation classification.

Further, slow and flat fading channels and non-Gaussian noises are considered. A new method to estimate symbol rate and phase offset of the unknown blind baseband signal is developed. The symbol rate is estimated using the spectrum of the instantaneous phase of the complex baseband signal. The phase offset is determined based on the symmetrical structure of the constellation.

A software-defined radio (SDR) based implementation of blind signal modulation recognizer (BSMR) on field-programmable gate array (FPGA) is developed. The system works without any prior knowledge of the received signal. The algorithm is deployed on NI-FlexRIO-7975 FPGA with the NI-5791 adapter using LabVIEW. The algorithm is optimized to use minimum hardware resources and facilitate future up-gradation. Signals for testing are generated using NI-PXIe-5673 (RF transmitter), and the system detects the modulation type in 81.451 msec under the AWGN channel.

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