COMP 6321: Machine Learning, Concordia University

PROJECT PROPOSAL FORM

Group: 08

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Propose a title for your project

Signal Detection Using Support Vector Machine Classifiers and Dimensionality Reduction Encoding for M-PSK Modulation Under Channel's Additive Noise

Describe the goal of your project

In this project, the main goal is to find a proper multi-class SVM classifier in M-PSK modulated symbols' detection (or demodulation). M-PSK refers to a modulation that modulates bits into M groups (symbols), and it deals with the phase of the symbols that transmit data through the communication channel. In the communication channel, the transmitted signals may be affected by additive noise. As a result, to preserve the performance of the SVM estimator, an encoding scheme is designed based on principal components (PCs) of the modulated signal, which can filter out additive noises and provide pure signals on the receiver side for the predictor.

The following block diagram is provided to describe the components that we are aiming to design:

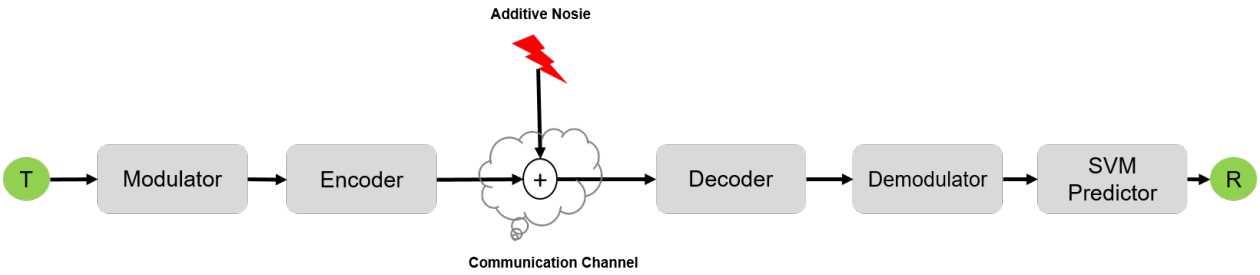

Figure 1: Block diagram-encoder block: for projecting data into a lower dimensional space- decoder: for projecting back the data into its original dimensional space

Describe the data you plan to use

In our work, the data set is generated with random functions. We suppose that we want to transfer a sequence of a large number of bits (e.g., 10^6 bits) through a simulated wireless telecommunication channel.

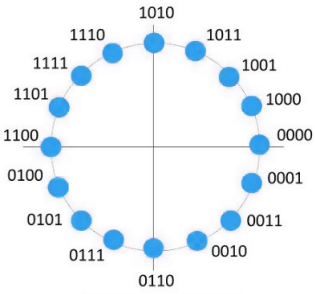

Figure 2: The constellation of the bits for an example of 16-PSK modulation

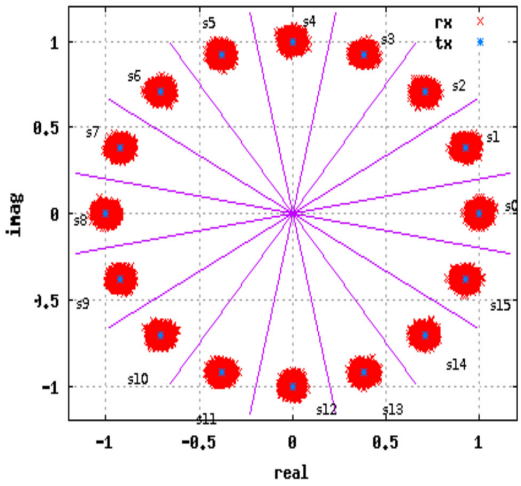

Figure 3: The expected SVM vectors for the 16-PSK modulation (image credit)

For this purpose, we will test our proposed method for the various groups (M) in M-PSK and compare the results. Thus, the generated data-set will contain M number of features. An example of 16-PSK modulation is shown in Figure 2. In addition, the channel suffers from AWGN additive noise which results in errors in received bits. This noise will be produced using a Gaussian density function and added to the primary data. Moreover, In a telecommunication channel transmission, usually some predefined bits (preamble bits) are transmitted in order to estimate channel status and then the original data is transmitted. We want to use the preamble bits as the training data and the original data bits as test data. It is worth to mention that, we need a preprocessing step on the data to model the encoder and decoder based on a dimensionality reduction method (PCA).

Describe how you will measure "success."

Usually Maximum Likelihood is used for detection of symbols which leads to a specific Bit Error Rate (BER). The success here is achieved when we are able to introduce a multi-class SVM for detection so that leads to less or equal BER compare to ML approach. Moreover, with this assumption that we have the actual labels, we can check the precision of the SVM estimator in the absence and presence of the additive noise by comparing the predicted labels with the actual labels.

Figure 3 shows the expected svm vectors for a 16-PSK modulation. In this figure, red dots are different symbols with AWGN noise and purple lines are SVM vectors which can be used as decision boundaries for bit detection.

Describe how work will be divided

Milad will design the telecommunication system model such as channel, bits, etc. (the dataset). Mina and Mehran will train the SVM and the encoding scheme (based on PCA), and Zahra will describe the achieved results by checking the performance of the trained SVM estimator in different scenarios.

List the main Python packages you expect to use

The list of the packages that we are going to use is as follows:

- Numpy
- Matplotlib
- Scikit-learn
- Pandas
- Scipy