EEL 6504

Project II

Due April 24, 2020

The purpose of this project is to detect manatee calls from real hydrophone recordings taken in an estuary. The data used for this project was collected by the Department of Biology at UF. In the course website you will find several data sets as follows: (1) a file (train\_signal.wav) with 10 different manatee calls segmented by the biologist that represent the signal class we would like to detect; (2) a 2 second noise background file (noise\_signal.wav) that represents the acoustic noise picked up by the hydrophone; (3) the continuous file (test\_signal.wav) with unsegmented manatee calls mixed with background noise that lasts approximately 30 seconds. The sampling rate is 48 KHz. The purpose of this project is to design and evaluate a machine learning detection approach to distinguish the manatee calls from the background.

There are many alternative ways to solve this problem, and here we will compare two procedures:

1. Create two adaptive models (linear or nonlinear), one to model the manatee calls and the other to model the noisy background. Each of these models will be trained as a predictor in the files that contains the 10 examples of the manatee calls, and the noisy background respectively. Once the two models are developed you apply both of them in parallel to predict the test data set. Since they were trained for different time structures, the predictor that has the smallest error should represent the corresponding class (noise or manatee). There is still a little problem because we need to smooth the prediction error in time because, as you can expect, the noise is high frequency, so a running average smoother is needed. The output created by the system will be a square wave for the full duration of the test set, with high meaning manatee and low meaning background.
2. Alternatively, just implement the SPRT and CUSUM tests explained in class to implement the segmentation in the two classes. Since you have knowledge of the classes in the training set, you can implement the supervised version of the tests. The issue that you have to check is if the time series is i.i.d. or requires a model to make the statistical test based on the prediction error.

The purpose is to compare the accuracy and the computational complexity of the two methods. Your role is to select in a principled manner the free parameters of both methods, i.e. in A: the predictors, the error smoother and to evaluate the performance of this system in the test set; In B: the size of the segments, the threshold and the number of log likelihood tests in CUSUM.

I suggest that you start with linear models in A and you can use either LMS, RLS trained with MSE or MCC in the input space or RKHS. You already have developed most of the MATLAB code! Regarding the error smoother you can use either a window or a recurrent estimator. As a first important step you should use DSP tools to help you understand the data structure and appropriately set the free parameters. The big difficulty is the variability of both the background noise and the manatee calls, which calls for small model orders. I suggest starting with M=3 and then go higher if needed. You also need to find a way to handle the data nonstationary in both classes by assemble averaging. The last problem is that we do not have a criterion to see if the predictors are correct or not, except by hearing the data (there are 16 calls)! Since you have the calls your ear can judge the quality of the decisions. You will have two types of errors, false and missed detections. The Receiver Operating Characteristics (ROC) is the best way to compare different solutions.

The project requires a report explaining the experimental procedures followed and you must include detection data, figures, and tables to support your conclusions. Please use the format of an IEEE Transactions paper (limited to 7 double column pages). This means you must write a brief intro to the theory, explain well the methods and present carefully the results and conclusions. Remember that any scientific paper should, by definition, contain sufficient information such others can replicate your results. A scientific paper must also contain ORIGINAL material only. If you happen to use text or equations from other source you have to reference what you cut and paste (this is not allowed in a normal publication, but here it is OK provide you reference). Of course, I expect the report (methods, algorithms, and results) to be done by the student ALONE.