ECE 5961/6961 Course Project Part II Requirements

In part II of the project, you will start working on the actual underwater data. The goal is for you to implement the two-step Doppler compensation algorithm in Matlab and apply it to the received underwater data to recover the frequency domain signals for each OFDM symbol. Further processing of these frequency domain signals will be the topics of part III of the course project.

Description of the underwater data:

You will be provided with two datasets, each corresponds to the received passband signals of an OFDM packet. There are 24 ZP-OFDM symbols in each OFDM packet, together with the preamble and postamble using LMF. Only signals from one receiving hydrophone are included in each dataset. You can download the two datasets from the Canvas page for Project Part II.

Task 1: Implement doppler compensation algorithm and recover frequency domain data

You will write Matlab codes to (1) Implement the Doppler compensation algorithm that includes resampling and carrier frequency offset (CFO) compensation, (2) Apply the Doppler compensation algorithm to process the received passband data and generate frequency domain symbols. Your implementation should follow closely to the provided guideline "Doppler-compensation-steps.pdf" to ensure successful processing of the underwater data. For each dataset, your codes should output the following:

(a) The estimated Doppler scaling factor $\hat{a}$ for the entire packet.

(b) Correlate the pilot signal with the received signal to determine the start of the signal transmission n_0 (occurs before the start of the first OFDM symbol due to the delay of the root raised cosine filter) and estimate the actual delay $\hat{n}_{0,1}$ between n_0 and the start of the first OFDM symbol in each packet.

(c) Jointly estimate the CFO ϵ_w and fine tune the starting index $\hat{n}_{0,w}$ for the w-th OFDM symbol, where $w = 1, \cdots, 21$.

(d) The resulting frequency domain signals $\mathbf{z_w} = \{z_{k,w}, k = 0, \cdots, K-1\}$ for the w-th OFDM symbol, where $w = 1, \cdots, 21$. These are obtained after applying the Doppler compensation algorithm with the optimized parameters found through steps (a)-(c) to the received passband data.

Please note that the estimated values for $\hat{a}$, n_0, ϵ_w, $\hat{n}_{0,w}$, and the resulting $\mathbf{z}_w$ after applying the Doppler compensation algorithm can differ to some extent, although they should fall into a certain range.

Task 2: Algorithm validation

You will validate the accuracy of your implementation using two datasets.

- The first dataset serves as a benchmark dataset, for which you will be provided with benchmark estimates of $\hat{a}$, n_0, ϵ_w, and $\hat{n}_{0,w}$ and the resulting $\mathbf{z}_w$ for each of the first 21 OFDM symbols in the packet. First, you may process this dataset using your Doppler compensation algorithm. It is likely that you may find your estimated values of $\hat{a}$, n_0, ϵ_w, and $\hat{n}_{0,w}$ to be close to the benchmark values, but not matching exactly. To help you validate the accuracy of your codes, you are then asked to run your Doppler compensation algorithm using the provided benchmark parameters $\hat{a}$, n_0, ϵ_w, and $\hat{n}_{0,w}$ to see whether the resulting $\mathbf{z}_w$ match with the benchmark $\mathbf{z}_w$ values perfectly. In the project page, you can find the following data files.
  - "benchmark_rece_data_174623_1472.mat" contains the received passband data for one OFDM packet that includes 24 OFDM symbols.

- "benchmark_parameter_174623_1472.mat" contains the benchmark estimates of $\hat{a}$, n_0, ϵ_w and $n_{0,w}$, which are labeled as "a_est_174623", "START_at_beginning_174623" "Epsil_Point_174623", and"Start_Point_174623".
- "benchmark_Zw_174623_1472.mat" contains the benchmark $\mathbf{z}_w$.
- "pilot_signal_for_synchronization.mat" contains the pilot signal used for synchronization (step (b) in Task 1).

- The second dataset is a test dataset. *No benchmark estimates of the parameters will be given.* Once you have validated your codes using the first dataset, you will apply your algorithm to the second dataset. You will need to carry out steps (a)-(d) given in Task 1 for this dataset. Once you finish it, please send your estimated parameters $\hat{a}$, n_0, ϵ_w, and $\hat{n}_{0,w}$ and the resulting $\mathbf{z}_w$ to the TA to check for accuracy.
  - "test_rece_data_173048_1472.mat" contains the received passband data from a second OFDM packet that includes 24 OFDM symbols.

Project Part II Check off

Our project TA Xiang Huang will meet each team individually for project part II check off. The deadline for project II check off is **March 22**. However, each team is strongly encouraged to do a **preliminary check off** with Xiang the week before to ensure that if something is incorrect, there will be enough time for code corrections and final project check off by March 22. We encourage in-person meetings for project check off and all team members should be present for the meeting.

Each team will send one copy of the Matlab codes to Xiang prior to the meeting. During the check off, Xiang will do the following.

- Ask you questions about the fundamental principles of resampling and CFO compensation. Ask you to explain the functionality of your Matlab codes.
- Ask you to run your codes to make sure that the outputs are correct.
- Ask you to explain the meaning of the figures or the results that you generated.

  Attention: While you are encouraged to contact Xiang for questions or to double check the accuracy of the results, please do your best to work with your team members to debug your team's Matlab codes. It would overload Xiang if every team asks Xiang to help with debugging. Thank you for your understanding and happy coding!