Compute a Synthetic Aperture SONAR Image

The goal of this assignment is to generate a SONAR image using synthetic aperture processing over a set of sound echoes obtained with a SAS instrument composed of a sound card, a directive loudspeaker and two microphones as depicted in figure 1. The instrument traversed a synthetic aperture of a few meters at an aproximately constant speed while producing a train of complex sound pulses and receiving the respective echoes. The target area is the low scattering carpet floor where three objects were arranged as displayed in figure 2. The Matlab file “sas_raw_rc.mat” contains two matrices, one for each microphone. These contain 700 echo vectors of 2205 samples each. The vector signals have already been converted to base-band and have been range compressed (correlation with the transmitted signals). The following parameters are relevant to obtain the image:

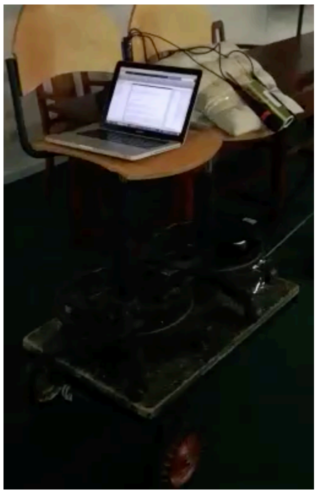

Figure 1 – SAS setup.

- The sound sampling frequency is 44100 sps.
- The sound carrier frequency is 10 kHz.
- The speed of sound is 340 m/s.
- The SAS instrument travelled at 0.16 m/s.
- The pulse repetition frequency (PRF) is 20 Hz.
- The target objects are situated between 2 and 3.5 meters away from the synthetic aperture.
- The synthetic aperture is roughly centred with the objects in the scene.
- The two microphones are situated to each side and close to the loudspeaker. They should produce two similar independent images.
- The beamwidth of the loudspeaker is about 30º.
- The echoes contain the direct signal (zero range) in sample index 100.

Figure 2 – Target area.

Since the data has already been range compressed, azimuth compression remains to be performed in order to produce the desired image. For this purpose, obtain the matching function for each range using the sound carrier wavelength and the instrument beamwidth information. Use the DFT/IDFT transform along the azimuth direction and for each range to efficiently perform the correlation corresponding to range compression. Given that correlations using the DFT are circular, extend the data matrix with zeroes to avoid overlapping. Extending to a length that is a power of two enables to use the FFT algorithm. Obtain the resulting image as the absolute values of this correlation. Remember to conjugate the transform of the matching functions when performing the correlation in the frequency domain. Remember also to compensate for the offset where you define the origin of the azimuth axis. As an additional task, beyond the native scope of the assignment, consider performing range migration correction to the data, in the frequency domain.