Matlab-exercise: spectral analysis of recorded data

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One of the key methods in radar data analysis is to study the spectra of received signals. In this exercise, the purpose is to get familiar with spectral analysis tools in Matlab. The code can be used to analyse recorded data during the field work at EISCAT Svalbard Radar.

There are five sound files to be used in the exercise.

Task description

1) There are five example sound files: `demosample.wav`, `sample1.wav`, `sample2.wav`, `sample3.wav` and `cw_radar.wav`

2) Listen to each of the sound files
    a. Describe what you hear in each file with a couple of words
    b. Based on what you heard, what do you expect to see in the spectra?

3) Plot the spectrogram i.e. time vs. instantaneous signal spectrum
    a. Start with `demosample.wav`
    b. Compare with the example plot to see whether your code is producing similar results. If not, adjust the parameters for the spectrogram (see Matlab help for inspiration).

4) Analyse the results
    a. Do you see strong signals?
    b. Are there multiple signals?
    c. What frequencies can you measure from the plot?
    d. Can you explain "everything" you see in the plot? Weird spikes etc.?
    e. Experiment with parameters: which parameters provide best results? (why do you think so?)

5) During the fieldwork, you will build a small radar and use it to measure speeds and distances. In the Continuous-Wave (CW) mode, the radar measures the Doppler shift in the received signal caused by movement. In this case, the radar was placed at the back of UNIS to measure the speeds of cars on the road. The radar frequency was set to 2.45GHz.

    Were any of the drivers speeding i.e. going over 50km/h?

    The measurement data is in `cw_radar.wav`. Use spectral analysis to analyse recorded speeds. This program for this analysis is particularly useful during the fieldwork.

An example spectrogram for the file `demosample.wav` can be found in the file `demosample.png`

- The data record length is five seconds
- (by listening) There is a single tone that starts from a low frequency and rises to a high frequency towards the end of the recording
- (from spectrogram) There is a frequency "sweep" that starts from roughly 150Hz and linearly increases to about 15kHz. The frequencies were determined from the plot by zooming in to see details.

Hints:

- There are many ways to analyse the spectrum of a signal as a function of time. Good candidates for this exercise are those based on short-time Fourier transform or wavelet transforms.
- All methods have a number of parameters to be selected and/or adjusted by the user: explore their effect to "dig into" the data to see all small details
- Use Matlab's help (and Internet) to find example code ☺
- You need to know the sampling frequency of the sound files in order to get correct frequencies

- If you'd rather use python or some other software on your own computer, it is completely ok as long as you know what you are doing and get correct results

- In particular for measuring the Doppler frequency, you may want to first find out the expected frequency range and then "zoom in" the spectrogram.