ECE 417 Lab Exercise # 6

Tone detection to decode telephone numbers

In this lab you will investigate telephone touch-tone signals used to represent different digits used in dialing. Each digit is represented with a distinct pair of sinusoids. You will use this information in figuring out unknown phone numbers from signals containing a string of digits. You will:

- process tone signals for each digit to determine the two sinusoidal components of each digit, and
- process a signal consisting of a dialed string of unknown digits and determine the digits and the order in which they appear.

1 Tone detection to decode telephone numbers

Below is some sample code to load signals:

```
load tones              % loads the data from tones.mat
load telephone_numbers     % and telephone_numbers.mat
whos                    % shows Fs, {tpn0,...,tpn4},
                        % and {u0,...,u9} (ten digits)
```

Here is a brief description of the data available to you:

- `Fs` is the sampling frequency, 8192 Hz.
- `u0,u1,...,u9` are signals representing digits $0, 1, \ldots, 9$ respectively. These are provided so that you can compare their spectra, and find out the "code", i.e. the way the spectral components encode the digit. You may use `fft` command and `plot/subplot` to plot the magnitudes of these spectra. Following is an example.

  ```
  U3 = abs(fft(u3));      % example for computing and plotting
  plot(U3)                % the spectrum "signature of digit 3"
  ```

- `tpn0,tpn1,tpn2,tpn3,` and `tpn4` are signals containing five different 4-digit phone extensions. Pick only one signal, with the number in its label given by your UIN *modulo* 5. For example, if your UIN ends with 24, pick signal `tpn4`.

Use Matlab commands to decode telephone number. You may try different methods, but try to figure out a reliable approach. You may "cheat" a little and first plot the `tpn#` signal to figure out where each digit information resides (in time) for the four digits in the signal containing the unknown phone number. However it is preferable to find the digit boundaries with a suitable technique like using an energy threshold to estimates the boundaries of the signal sample segments in which each digit information resides.

Q6.1 Determine the frequencies of the pair of sinusoids in each of the signals `u0,u1,...,u9`representing the digits $0, 1, \ldots, 9$. Show a plot of the frequency content of the signal for each digit.

Q6.2 Explain the method you devised to determine the unknown phone number. List all the steps in your method.

Q6.3 List the digits in the order you obtained. Submit an electronic version of your code to the TA. Do not copy code from other students and do not re-use code from past years.

2 Variable-duration digits and noisy data: Tone detection to decode telephone numbers

In this lab exercise you may have assumed knowledge of digit signal boundaries and that each digit is of the same duration. In practice the dialed tone duration is variable and user-dependent. Some people may press the keys longer and with uneven digit duration. A good detector design should factor in such variations.

Q6.4 Now consider relaxing this assumption, and assume no knowledge of the boundaries of the time intervals where the digit information resides. Describe ways of modifying the procedure to figure out where each digit information resides (in time).

Bonus exercise: The five given signals `tpn#` are "clean signals" with no noise. In practice noise may contaminate the signal. Add different amount of noise using the Matlab `randn` (Gaussian noise) command. First determining the number of samples in the `tpn#` signal and use it in running the `randn` command for creating the noise signal with the same number of samples as in `tpn#`.

Q6.5 (Bonus) Report your results on the detection after noise is added. Increase the noise until you start seeing errors. Report the ratio of the signal power and the noise power when you observe the error.

(Written by R. Ansari. Updated F22)