Homework 7 submission

ECET 512 — Wireless Systems

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1 Submitted files

For this assignment, this report and the archives outlined below were created or added to and submitted.

1.1 SRC Folder

+ *"mainMultiFading.m"*: The MATLAB script will run a simulation that accomplishes the goal of the homework. It generates a number of Rayleigh fading envelopes and determines values such as LCR, AFD and BER vs SNR.

+ *"mainMU.m"*: This MATLAB scripts conducts the experiment of plotting BER and SNR vs user distance based on a non-trivial trajectory throughout a single cell system.

+ "*rayleighFading.m"*: This function returns a time-series representation of a Rayleigh fading envelope realization given parameters for maximum Doppler frequency and number of samples.

1.2 DOC Folder

+ *"mobile_user_video.avi":* This is a video that shows the mobile user moving through the single cell space within the area.

+ "*SNRvsPosition.png*": This photo shows the plot of the signal to noise ratio for each frame of the mobile user moving through the single cell system.

+ "*BERvsPosition.png*": This photo shows the plot of the bit error rate for each frame of the mobile user moving through the single cell system.

+ "*SNRvsBER.png*": This plot shows SNR vs BER for a particular case of sample Rayleigh fading envelopes for decoding a 4-QAM modulated sequence of random bits.

2 Code execution

The MATLAB programming language was used to create the simulations for this homework. To run the simulations, simply run the *"main*.m"* scripts. The scripts showcase the calculation of various envelope parameters in one script and shows an application of this in a mobile setting in the next script.

3 Homework Solution

3.1 Fading Statistics

The first part of the homework asked to generate 100 samples each of fading envelopes occurring for maximum Doppler shifts of 200 Hz (upper) and 20 Hz (lower). These envelopes were calculated and by running through each sample and taking averages, the level crossing rate and average fade duration was calculated for each case for two thresholds. The upper threshold was 0dB and the lower threshold was -10dB. Below in Figure 1 is a snapshot of the MATLAB script output displaying these parameters for each case for a particular run of the script.

```
Level Crossing Rate for ref_level=-10dB, doppler_max=20Hz is 0.071835
Level Crossing Rate for ref_level=0dB, doppler_max=20Hz is 0.71415
Average Fade Duration for ref_level=-10dB, doppler_max=20Hz is 5.0922
Average Fade Duration for ref_level=0dB, doppler_max=20Hz is 48.017
Level Crossing Rate for ref_level=-10dB, doppler_max=200Hz is 2.4603
Level Crossing Rate for ref_level=0dB, doppler_max=200Hz is 56.4693
Average Fade Duration for ref_level=-10dB, doppler_max=200Hz is 0.21181
Average Fade Duration for ref_level=0dB, doppler_max=200Hz is 0.82362
```

Figure 1: Output for each case of max Doppler shift and threshold level for one hundred generated Rayleigh fading envelopes.

3.2.A Bit Error Rate

The next problem asked to plot the SNR vs the BER following the steps outlined in the homework paper. Following these steps for SNR values from -20dB to 10dB the BERS were calculated. A snapshot of the generate plot is found below.

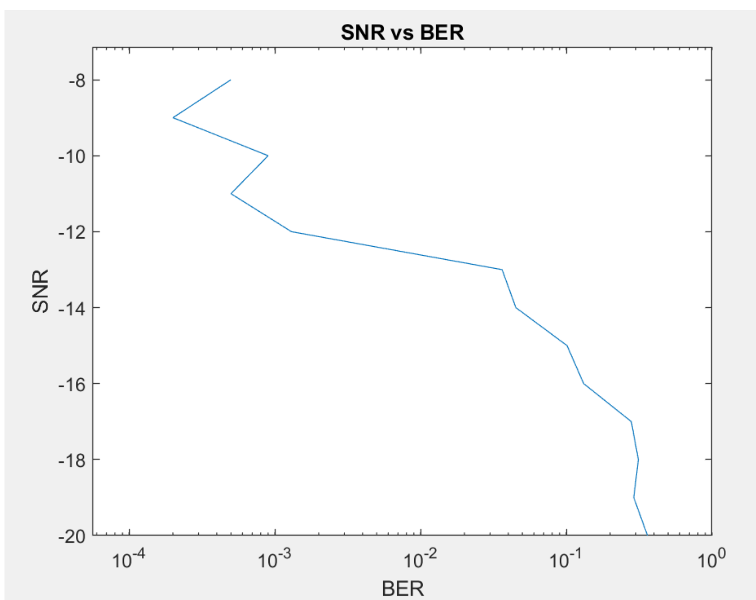

Figure 2: Plot of SNR vs BER for a number Rayleigh fading envelope realizations.

The plot shows the BER plotted on a log axis to better showcase the range of values that it shows from about On some occasions the BER can be as low as 10^-4 in cases where there is only one error in the ten thousand bit bitstream. As the signal to noise ratio increases the interference caused by random noise modifies the transmitted symbol less thereby decreasing the bit error rate. The advantage of using a quadrature amplitude modulation scheme is that in the constellation diagram, the symbols are moved around less by the noise and are able to be properly decoded much easier. Also take note that not all SNR values are shown in the plot since at most of the larger SNR values the BER dropped to zero with no errors in the recovered bit stream. As can be seen again the QAM scheme is rather resistant to noise in cell systems where it is implemented.

3.2.B Mobile User Simulation

As has been done many times in the past, this simulation spawns a single mobile user moving passed a base station in the middle of a single cell cluster. I have omitted the figure of the stand-still of the movie for convenience though the movie of the mobile user traversing the cell can be found in the 'doc' folder. For this simulation the same analysis was taken as in the previous part but for each point in the user's trajectory. At each point another realization of the fading channel was used to modify the signal that is attenuated with a noise component computed by the pathloss model. The plots for the SNR and BER as a function of mobile position are shown below. Note that for this problem the user moves passed the base station so as to not make it too trivial of a case.

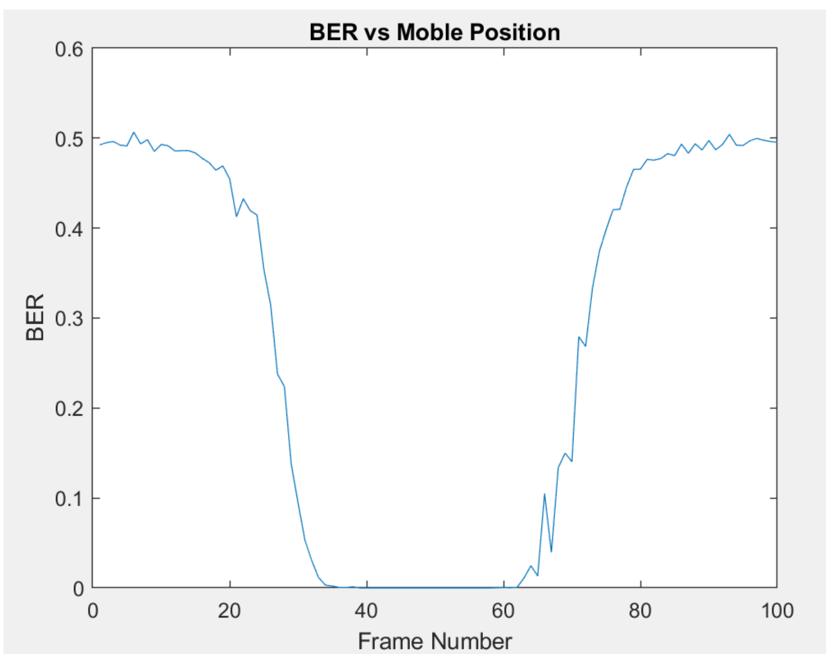

Figure 3: Plot of the bit error rate as the mobile user moves passed the base station. When the signal to noise ratio is greater near the base station, the bit error rate is lowest.

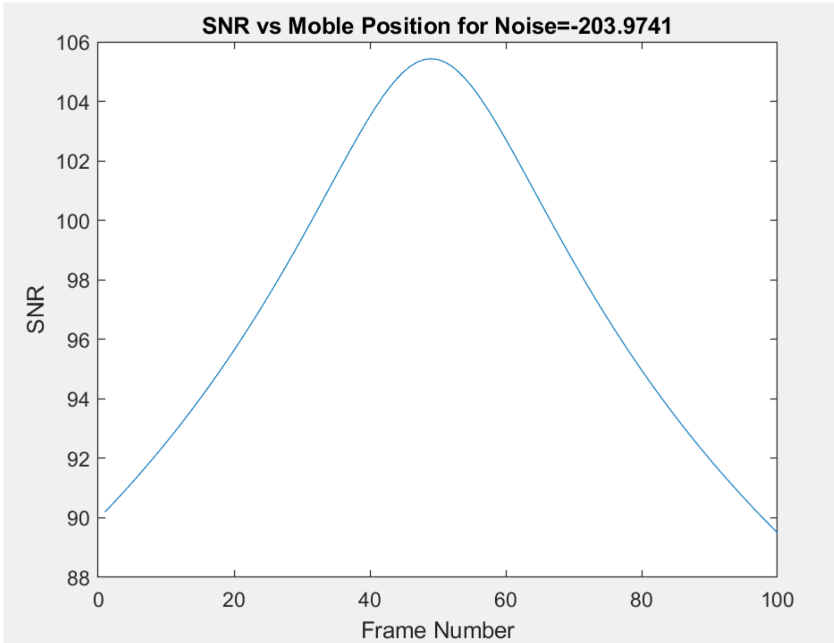

Figure 4: Plot of signal to noise ratio as the mobile user moves passed the base station. It is greater the closer the mobile user gets since the received power is greater at this point.

For this simulation the radius was set quite large so as to see the effects of the subtle differences in the SNR at each position and how it affects the BER. When the user is closer to the base station the signal to noise ratio is greater. When the SNR is large the bit error rate is low because the signal is 'louder' than the noise that falls below it. The plots reflects this.

3.3 MATLAB Movies

To view the movie illustrating the movement of the mobile user, refer to the flicks found in the DOC archive.