

Computer Homework #2: Speckle Statistics

Due 24:00, 11/16/2017

Part 1. Verification of speckle statistics

(a) Create an array of 10,000 complex data with the following statistics:

- (i) Uniform distribution of amplitude in $[0, 1]$.
- (ii) Uniform distribution of phase in $[0, 2\pi]$.

Plot the histograms of the amplitude and intensity of the above data

(b) Create a new array of N data points based on the original array ($N=10,000, 5,000, 2,000, 1,000$ and 500). The i^{th} point of the new array is the sum of M consecutive data points ($M=1, 2, 5, 10$ and 20) of the original array (from $(i-1)*M+1$ to $i*M$). Plot the histograms of the amplitude and intensity of the new arrays (at least for $M = 1$ and 10). Calculate and plot the ratio of the mean to the standard deviation of the amplitude and intensity arrays as a function of M .

(c) Repeat (a) and (b) by making the phase distribution uniform between $[0, \pi]$ (for $M=1$ and 10 only).

(d) Suppose the amplitude array and the intensity array obtained in (b) are “smoothed” by a $[0.5 \ 0.5]$ moving average filter, calculate the ratio of the mean to the standard deviation of the two arrays. Justify your answers. (hint: in-coherent processing or post-detection filtering)

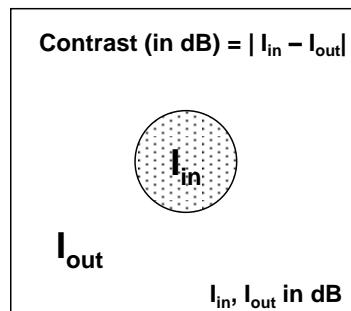
(e) Suppose the arrays with N data points obtained in (b) are “smoothed” by a $[0.5 \ 0.5]$ moving average filter, calculate the ratio of the mean to the standard deviation of their amplitude and intensity arrays. Justify your answers. (hint: coherent processing or pre-detection filtering)

Part 2. Field II simulation

“single_img.m” is a Field II simulation program, which simulate an ultrasound B-mode image of a tissue-mimicking phantom with a higher scattering inclusion. The tissue-mimicking phantom is defined in “cyst_phantom.m”. In “cyst_phantom.m”, the scatterers are uniformly distributed within a specified region, and the back-scattering amplitude is with normal (i.e. Gaussian) distribution. Use and modify these two Matlab codes to verify speckle statistics and the effects of speckles and scatterer distribution on the resultant B-mode images.

(a) Calculate the ratio of the mean to the standard deviation of the amplitude and intensity of the image data in the speckle background and the higher scattering inclusion, respectively. Compare your results with the theoretical values.

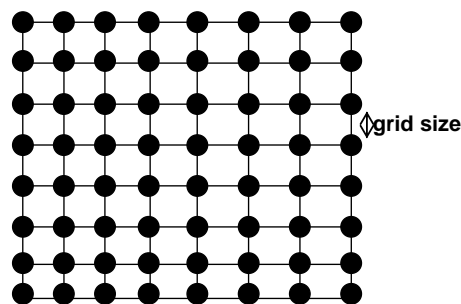
(b) Calculate the contrast in dB between the inclusion and background, and standard deviation in dB of the image intensity in the speckle background and the higher scattering inclusion, respectively. Compare your results with the theoretical values. The definition of “contrast”, please see the following illustration.



(c) Reduce the contrast between the inclusion and background gradually to see what the minimum detectable contrast of the ultrasound imaging system is. Justify your results.

(d) With the contrast between the inclusion and background smaller than the minimum detectable contrast explored in (c), change the diameter of the higher scattering inclusion. Can you detect the inclusion better with a larger diameter? Justify your answer.

(e) Modify “cyst_phantom.m” to have a phantom with periodically located scatterers, as illustrated in the following figure. Change the grid size as one wavelength, two wavelengths, and ten wavelengths. What do you observed from the resulted B-mode images? Justify your findings.



(f) Compare the Fourier spectra of the RF A-lines obtained from imaging the tissue-mimicking phantom and the phantom in (e), respectively. Justify your findings.

Part. 3. Bonus (not required)

Use the programs to investigate any issues relevant to this topic. For example, explore the effect of the scatterer concentration in the inclusion of the tissue-mimicking phantom in Part 2 on the B-mode images.

Notice:

1. Name your solution word file as “EE6265_HW2_StudentID.doc” and your Matlab codes as “EE6265_HW2_StudentID.m”, and archive all the files into a zip or rar file.
2. Please upload your zip/rar file to the LMS elearning system
3. The first line of your word or Matlab file should include your name and some brief description, e.g., % EE 6265 王小明 u9512345 HW2 11/16/2017
4. Don't just show me the results. Please justify the results you've obtained.
5. You can download the Field II toolbox for your MATLAB version at <http://field-ii.dk/>
6. <HINT> useful matlab functions: rand(), hist(), and conv().
For hist() (or histogram), please use at least 20 bins.