生醫影像導論

Introduction to Biomedical Imaging

(10510EE 441000)

Homework #1 Part 1: Envelope Detection, and PSF Evaluation

Due: 24:00, 11/08/2016

1. After mechanical scanning 5 point targets with a single element transducer, we obtained the ultrasound raw/rf data set: “points_rf_data”. The experimental parameters are listed in the following:

- Depth of the 5 point targets: 6 mm, 9 mm, 12 mm, 15 mm, and 18 mm with respect to the depth of the transducer surface (the depth of the transducer surface: 0 mm)
- Time offset (i.e., the data acquisition time of the first data point): 6.48 μsec.
- Sampling rate: 50 MHz samples/sec.
- Aperture size of the transducer: 6 mm
- Distance between two successive scanning positions: 50 μm
- Speed of sound: 1.54 mm/μsec

(a) Ultrasound image formation: follow the procedure of ultrasound image formation in the lecture notes to form an ultrasound image of the 5 point targets with 40 dB dynamic range and correct image axes (correct depth and lateral position). (procedure: envelope detection with Hilbert transform, log conversion, and then determine the image dynamic range)

(b) Find the focal length (i.e., depth) of the transducer according to the image you make in (a). One of the point targets is located at the focal point.

(c) Point spread function assessment: determine the lateral and axial resolution at the depths of the 5 point targets based on the fundamental definition of the spatial resolution and your eye examination. Does the imaging system own the best lateral and axial resolution at the focal point?

(d) Point spread function assessment: determine the -6 dB and -20 dB lateral and axial resolution at the depths of the 5 point targets using projection along the corresponding direction, and compare with the results in (c). Please comment your findings.

(e) Compare the theoretic lateral resolution (i.e., -6 dB mainlobe width) at the focal point with your results in (d). Note that to find out the theoretic lateral resolution, you have to figure out the center frequency of the transmitted signals by the transducer. Please show how you figure out the center frequency.

(f) According to your results in (c) and (d), is the resolution "position dependent resolution"? Please discuss with axial and lateral resolution, respectively. It would be better that you can provide the plots of axial or lateral resolution as a function of depth, and discuss according to the plots.

(g) Can you decide that the point being imaged is located in front of, right at, or after the focal point via its PSF shape? How and why?

2. Given a 2D point spread function (PSF), describe what features of the 2D PSF determine the axial, lateral, and contrast resolution in ultrasound imaging, respectively, and what imaging parameters determine the 2D PSF features you describe?

(Hint:

(1) Envelope detection with Hilbert transform
Matlab function: "hilbert()"

(2) Matlab codes to show an image with 40 dB dynamic range:

```
envelope_dB = 20*log10(envelope/max(max(envelope))+eps);
image(envelope_dB+40);
colormap(gray(40));
colorbar;
```

(3) You can load all the provided data directly in Matlab by using "load filename"

(4) For (c) and (d), you may need to interpolate the data, which can be done by using the MATLAB functions: imresize(), interp1() or resample().

(5) For (c), you may need to "convolve" the data with the provided point spread functions, which can be done by using the MATLAB functions: conv() or conv2().

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Notice:

1. Please hand in your solution files to the LMS elearning system, including your word file of the detailed solutions, the associated Matlab codes, and all the related materials. It would be nice that you can put your codes with comments side by side along with your answer in the word file.
2. Name your solution files "EE4410_HW1_Part1_StudentID.doc" and

"EE4410_HW1_Part1_StudentID.m", and archive them as a single zip file: EE4410_HW1_Part1_StudentID.zip.

3. The first line of your word or Matlab file should contain your name and some brief description, e.g., % EE 441000 王小明 u9612345 HW1 Part1 11/08/2016
4. Note that if you use "baseband demodulation" for the envelope detection correctly, you will get 5% bonus. You may call Matlab routine "fir1()" for your filter design.