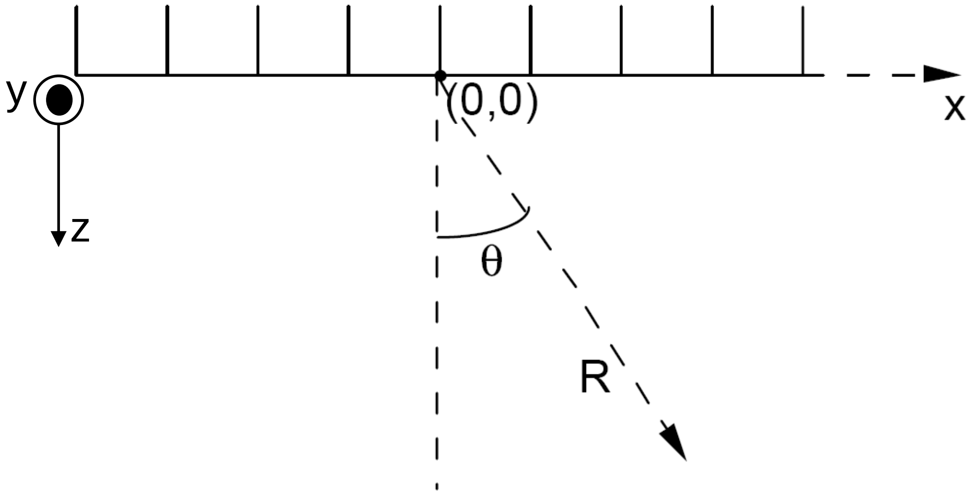
生醫光聲原理

Computer Homework #1 Part1: Beam Formation – Single Element Synthetic Aperture Focusing

Due 24:00, 01/02/2018

Considering the following ultrasound **phased** array system:



For simplicity, the array illustrated above has only eight elements. You will simulate channel data from a 65 element array, but using the same geometry. That is, the origin of the coordination system is at the center of the middle element. The important parameters for this array are:

Number of elements = 65;

Impulse response of each element: Gaussian pulse with center frequency (i.e., fc) = 5.0 MHz and 70% fractional bandwidth;

Element spacing (i.e., dx) = 0.150 mm, which is half of the wavelength at fc.

(1) You will use this array definition to simulate acquired channel data for 3 point targets. The channel data can be generated with the following assumptions and procedures.

a) The transmitter (i.e., each array element) is a perfect point source

b) The receiver (i.e., each array element) is a perfect point receiver

c) There is no attenuation. That is, the received signal does not need to be gain compensated.

d) The sound speed is 1.5 mm/us or 1500 m/s

e) The complete channel data are collected with consecutive single element transmitting and receiving. That is, the complete transmit (tx) and receive (rx) sequence is as follows:

element 1 tx/rx (start)

element 2 tx/rx

…

element 65 tx/rx (end)

Note that the impulse responses of each element on tx and rx have to be considered.

f) The position of the 3 point targets in (x,y,z): (-5, 0, 10), (0, 0, 20), (15,0,30) in mm.

g) The initial sampling rate (i.e., fs) is set to 64*fc to emulate "analog" channel data

h) Perform decimation on emulated "analog" channel data so that the resultant sampling rate (i.e., fs) is 4*fc on "sampled" channel data

i) Make wavefield plots of the "analog" and "sampled" data (i.e., image of channel data). The gray scale is setup so that zero pressure is midgray, positive pressure is white, and negative pressure is black.

(2) Implement RF and baseband dynamic receive beamformer to make a 120-degree sector scan image from the sampled channel data.

a) Define the beam spacing (in $\Delta\sin\theta$, e.g., $\boldsymbol{\Delta\sin\theta = \lambda/2D}$, where D is the full array aperture size, and λ is the wavelength at fc) and the number of total beams to properly sample a 120-degree sector.

b) Perform RF and baseband beamforming, respectively. Show the signal spectra in each step of baseband demodulation by FFT (required for RF beamforming only).

c) Create baseband data for the R-sinθ beam buffer by computing the coherent sum across the array

d) Create baseband data for the R-sinθ beam buffer by computing the coherent sum across the array aperture with hanning apodization. (Matlab function: hanning())

e) Create baseband data for the R-sinθ beam buffer with the beam spacing $\boldsymbol{\Delta\sin\theta = \lambda/D}$ (required for either RF or baseband beamforming only)

f) Create baseband data for the R-sinθ beam buffer by computing the coherent sum across **every other** element (required for either RF or baseband beamforming only).

g) Display the content of the R-sinθ beam buffer as a gray scale image over a logarithmic scale of 40 dB (i.e., 40 dB dynamic range). Compare your answers of c) with RF beamformer and baseband beamformer, c) and d), c) and e), and c) and f), respectively (required for either RF or baseband beamforming only). Explain your findings.

h) Scan convert the above R-sinθ beam buffers in c), d), e) and f) to produce sector scan images for 512 by 512 pixel grid, and then display over a 40 dB dynamic range. The sector should be to a range of 40 mm. This means that the dimension of each pixel in the final image should be $\Delta x=\Delta z=(40/512)$ mm. Again, compare your answers of c) with RF beamformer and baseband beamformer, c) and d), c) and e), and c) and f), respectively (required for either RF or baseband beamforming only). Explain your findings. <HINT: scan conversion with Matlab functions: interp2() or pcolor())

i) Pont spread function assessment: determine the -6dB and -20 dB lateral and axial resolution at the depth of the 3 point targets using projection of the post scan-conversion data along the corresponding direction (required for either RF or baseband beamformer only), and then compare with the theoretical lateral and axial resolution.

j) Explore the differences of baseband beamformers with and without phase rotation, such as the difference in images or resolution (i.e., focusing quality). Elaborate your findings.

k) Explore the differences of delayed channel data between on-axis and off-axis point targets, and elaborate the reasons. (required for RF beamformer only)

Notice:

1. Name your solution word file as “EE6265_HW1_Part1_StudentID.doc” and your Matlab codes as “EE6265_HW4_Part1_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 HW4 Part1 MM/DD/YYYY
4. Don’t just show me the results. Please justify the results you’ve obtained.