BMEN 509 Introduction to Biomedical Imaging

Laboratory 3

Ultrasound Image Formation - Tutorial and Questions

1 Purpose

The purpose of this laboratory is to become familiar with physical means to form an image using ultrasound waves. In this exercise, you will demonstrate:

1. a basic understanding of the principles of reflection of an ultrasound wave,
2. understanding how ultrasound signals are processed to obtain intensity and form an image,
3. practice filtering an ultrasound image.

2 Ultrasound Transducer Characteristics (/9)

Observe the transducer provided for the laboratory and note the main characteristics that will influence the image that you can obtain. List at least 3 main characteristics and briefly mention to which image characteristic they are linked. The transducer will then be mounted into the holder and placed in from of a target.

3 Acquisition System (/40)

The connections of the transducer to the excitation and acquisition instruments will be then made. Read the lab notes to have a description of those instruments and their purpose and observe the connections made. In your report you will need to make a brief set-up methodology description with schematic drawing of these connections.

Safety: The conductivity of the water will be measured to ensure it is below $2\mu S$

Safety: We will avoid putting our hands in the water while you sending energy

Safety: All electric devices will be connected to a GFCI that was tested first. No other electric devices should be around the water tank.

Safety: Any spilled water must be dried before energizing any device

Safety: Hands should always be dry before operating any device

All the equipment is then turned on and the acquired line can then be observed on the oscilloscope. The trigger levels, voltage and time division will be adjusted. The transducer is then moved using the manual slider to a position where the initial line will be registered for the image.

1. Lines will be then acquired and saved as a file in the oscilloscope
2. Movements of $1mm$ sideways will be done and the acquisition is then repeated
3. Once 10 to 20 lines are acquired there is enough data to form an image
4. All your files will be put on D2L
5. Note that you will be assigned a random acquisition for one of the targets in the lab that you will be using for your report on the provided Notebook

Answer the following questions:

1. At which time do you register the first echo from your target?
2. Calculate the distance at which your target was placed
3. Zoom into the signal that is acquired and calculate the frequency
4. What do you observe if you move the target and transducer closer? Why?
5. What do you observe if you modify the filters in the pulser/receiver? What value you chose for filtering and why?

4 Image Formation (/22)

The provided notebook file is ready to form your image provided you modify the code appropriately to open the files that you generated. Test the notebook and the features first using the provided data.

Modify the code to open your own files and run the notebook.

Answer the following questions:

1. Is the frequency calculated with the notebook close to the values you calculated in 3? Explain.
2. Is the frequency close to the value expected for this transducer? Why?
3. Discuss why the reflectors in the image do not look like perfect points
4. Make a sketch of the steps in the code used to form the image including the names of the functions used
5. Provide an explanation what is the **Hilbert** transform and how is the function used in the code
6. Compare your reconstructed image to the one formed with the provided data and list two differences explaining what changes in the experimental settings may explain the differences

5 Image Filtering (/25)

The notebook provides code for filtering the formed image. Modify some parameters in the code so observe the changes you obtain in the resulting image.

Answer the following questions:

1. What is the effect of increasing the kernel size of the filter?
2. What is the effect of modifying the cut levels for the image?
3. Can any of the features in the image be seen appropriately without logarithmic scaling? Why?
4. Why was the value of attenuation fixed to $0 Np/m/MHz$ for this code?
5. What is the line in the code that performs TGC?

6 Rubric

Please submit a report summarize the results of each part of the lab, including answering the questions at the end of each section. The report should include an objective and conclusion. Please submit your modified code with your report. Reports without code will receive a zero.

Criterion	Marks
Code is commented appropriately	/2
Report is well formatted with name, date, objective and conclusion	/2
Question 1: Three characteristics identified /3 Linkage to image properties /6	/9
Question 2: Set-up methodology complete with schematic and safety considerations /20 Signal acquisition considerations described (i.e. trigger, timing, level) /10 Questions /10	/40
Question 3: Notebook appropriately modified to form an image with acquired data /10 Questions /12	/22
Question 4: Notebook appropriately modified to filter/display the image with acquired data /10 Questions /15	/25