11/20/2019

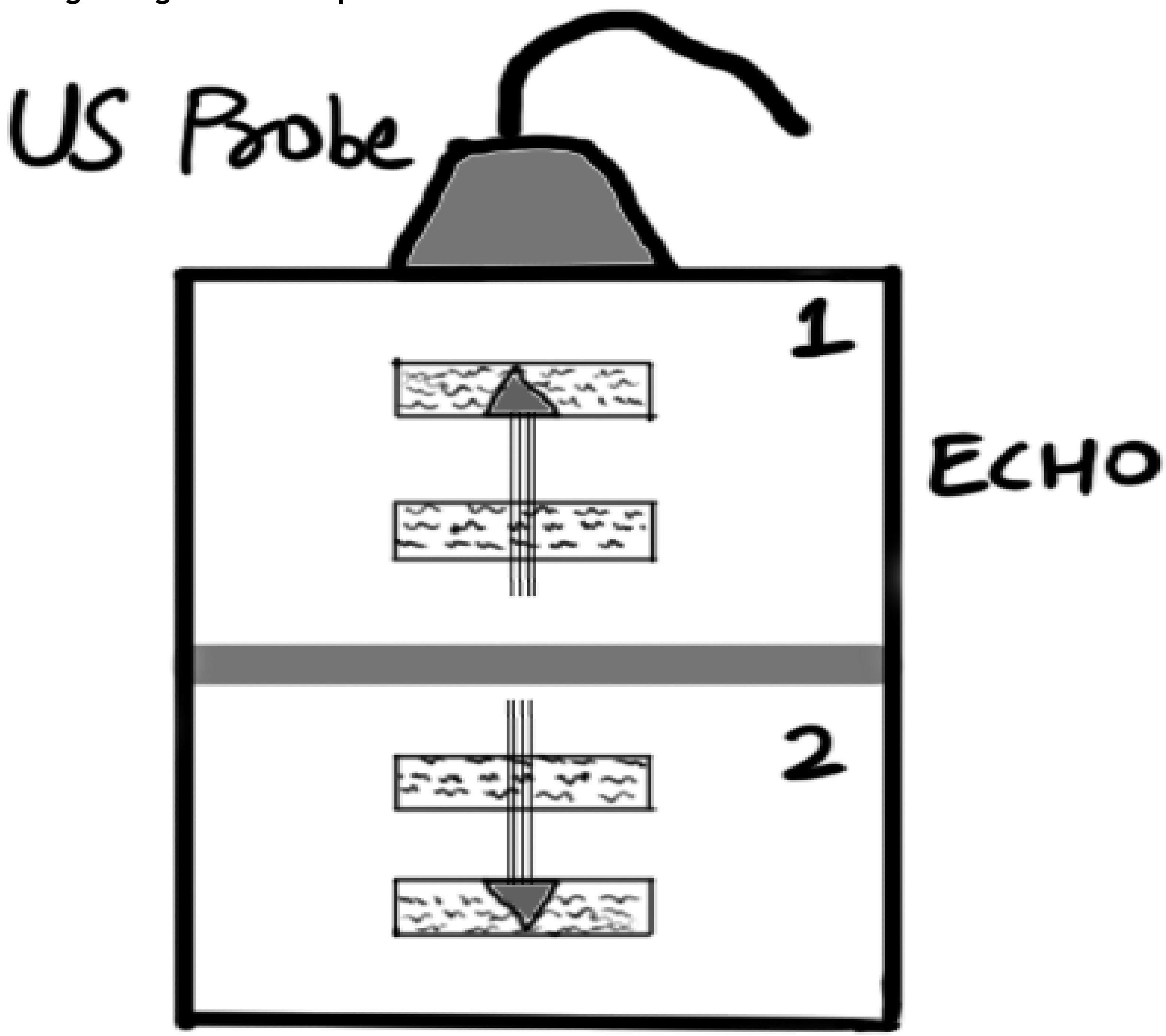
2D Ultrasound Report

COSC-4372(Fundamental of Medical Imaging)

Report

Question-1: In this project, you want to produce a 2D image of the phantom. (a) How can you do that with a single beam US probe? (b) Make a simple diagram of the hardware components involved with the receiver channel of the Ultrasound probe.

- **The Ultrasound uses soundwaves to create images. The single beam ultrasound probe also called transducer contains a quartz crystal in it, i.e.-piezoelectric crystals. Once the crystal encountered electric current it starts to change its shape precipitously. These rapid change in shape are the one which produces waves of ultrasound. When the probe sends ultrasound waves to patient body, the sound wave is reflected to the probe, by boundaries between different organs and tissues recording strengths and position of these echoes. When these echoes hit the transducer, they generate electric signals that are send to ultrasound scanner.** Using the speed of sound and the time of each echo's return, the scanner calculates the distance from the transducer to the tissue boundary. These distances are then used to generate two-dimensional images of tissues and organs. **Piezoelectric crystal installed inside the probe also affects the shape and quality of the image. In this way, the 2D image of the phantom using a single beam US probe is constructed.**



- Refrence-Lecture Notes

Question-2: Assignments 1 and 2 have same phantoms and similar scanner setups: why does one produce a 1D image and the other 2D images?

- **In Assignment 1, we did produce 1D image because in the x-ray scanner setup we didn't consider time since the x-ray passes just one time for the image formation. However, in assignment 2, Ultrasound's probe produces different echo continuously while passing through different tissues and organs over time. So, we must consider time which adds another dimension. Though having the same phantom, it produces 1D image for x-ray and produces 2D image for ultrasound.**

Question-3: How many parameters are needed to be defined for this phantom to be used in ultrasound?

- **We need three parameters to be defined for this phantom to be used in ultrasound. They are attenuation, speed and length.**

Question-4: (a) What determines the resolution of your 2D image (link to the answers of Questions 1(a) and 1(b))? (b) How can you adjust it?

There are different factors that can determines the resolution of the 2D image.

- **Movement of Probe: One factor is that how we move the probe while scanning. If we move too fast, it is hard to get finer resolution image but if we move the probe with smaller steps, we get finer resolution.**
- **Sensor Quality: The dimension of the image is determined by how often we can sample with our sensor. Cheaper sensor is unable to sample as often so will obviously have lower resolution. Therefore, using a good sensor is helpful so that we can get higher resolution image.**
- **Focusing: Piezoelectric crystal elements in a transducer operate different times and can narrow the pulse beam with improved lateral resolution. Narrowed and focused beam generates high resolution of the image. It can be adjusted according to the needs, so narrowing down will help in increasing the resolution.**

Question 5: How should you modify your code so that you can generate the ultrasound image from a virtual human with 30 organs?

- **In order to generate the ultrasound image from a virtual human with 30 organs, we will have to change the attenuation and speed accordingly. So, in this case, we will need 30 attenuation and 30 speed in the code.**

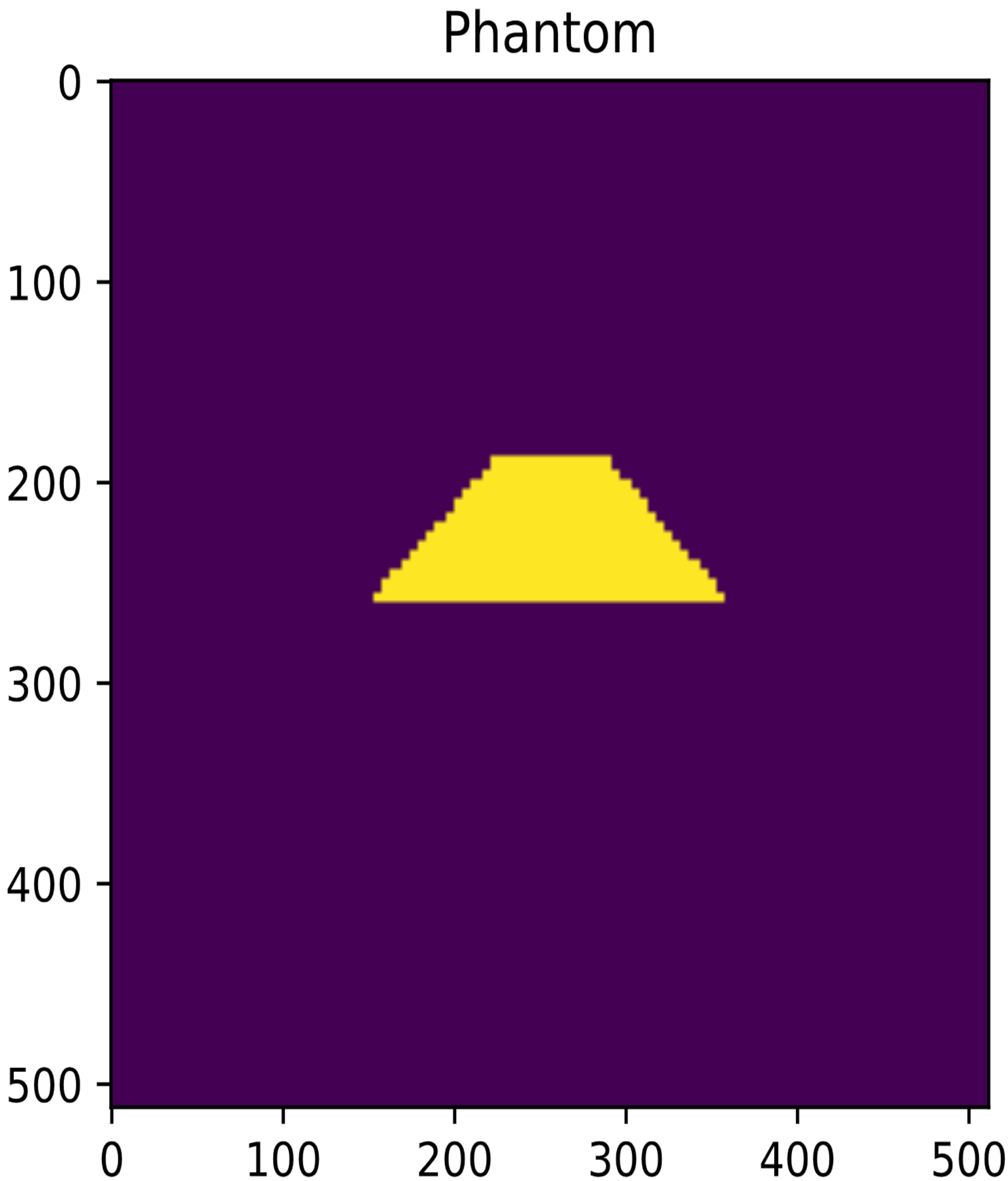
Input Values:

- **Initial Dimension: 512*512 pixels**
- **Length: 10 cm**
- **Attenuations:** `[0.48(fat), 1.09(muscle)]`
- **Speeds:** `[(1460(fat), 1580(muscle)]`

Images for code used to create Phantom

```
def generate_phantom (x,y,length,attenuations, speeds):

    # Create phantom matrix, U matrix, L matrix
    phantom = np.zeros((y,x), np.uint8) # phantom image
    U = np.zeros((y,x), np.float32) # attenuation matrix
    S = np.zeros((y,x), np.float32) # speed matrix
    L = np.ones((y,x), np.float32) # length matrix
    L = L * length / x # how many cm per pixel


    # Trapezoidal Phantom will have 15 loop structures
    # Structures will have relative positions
    a = 0.50
    b = 0.51
    c = 0.30
    d = 0.70

    for k in range (1,15):

        struct_k = np.zeros((y,x), np.float32)
        struct_k[int(y*a):int(y*b),int(x*c):int(x*d)] = 1
        phantom += struct_k.astype(np.uint8)
        U+= struct_k * attenuations[0]
        S += struct_k *speeds[0]
        a = a - 0.01
        b = b - 0.01
        c = c + 0.01
        d = d - 0.01



     # Add the structures to the phantom
    phantom *= 255

    # Write a phantom
    cv2.imwrite("phantom.jpg", phantom)

    # Add structure attenuations to U matrix
    U[np.where(U == 0)] = attenuations[1]

    # Add structure speeds to S matrix
    S[np.where(S == 0)] = speeds[1]

    return phantom, U, S, L
```

Images from Phantom of 512*512 pixels resolution:



2D Ultrasound image formed: