11/30/2019

Virtual Scanner - Report

COSC-4372(Fundamental of Medical Imaging)

Question-1: In this project, you want to alter contrast between the different parts of the virtual human. (a) What are the tissue parameters and what are the scanner parameters? (b) How can you do that with the MRI? (c) Can you do this and How about with X-rays or Ultrasound?

a) **The tissue parameters are:**
   i) **The repetition time (TR) - The length of time between corresponding consecutive points on a repeating series of pulses and echoes**
   ii) **The echo time (TE) - The time from the center of the RF-pulse to the center of the echo. For pulse sequences with multiple echoes between each RF pulse, several echo times may be defined and are commonly noted TE1, TE2, TE3, etc.**
   iii) **Spin Density[H] - True spin density is not imaged directly, but must be calculated from signals received with different interpulse times**

   and the scanner parameters are:

   i) **Gradient**
   ii) **Magnetic Field Strength[T]**
   iii) **Field Offset**

b) **In order to alter contrast between the different parts of virtual human in MRI for this project, we can change the value of echo in the code. As we know, MRI records the echo strength along the time for the formation of image. Hence, the strength of signals plays important role in formation of contrast image. Also, we can use Gadolinium contrast media, which are chemical substances used in magnetic resonance imaging (MRI) scans that helps to alter the contrast of the different parts of tissue. When injected into the body, gadolinium contrast medium enhances and improves the quality of the MRI images (or pictures).**

c) **Yes, it is possible to alter the contrast in X-ray and Ultrasound as well, but it might not be as flexible as in MRI. In MRI, we can use the contrast agent, but X-ray might need the adjustment of the beam that is emitted.**

Question-2: How many tissue parameters are needed to be defined for this phantom to be used in MRI SE?

- **Spin Echo sequence is based on repetition of 90° and 180° RF pulses. Spin Echo sequence have two parameters for this phantom:**
  a) **Echo Time (TE) is the time between the 90° RF pulse and MR signal sampling, corresponding to maximum of echo. The 180° RF pulse is applied at time TE/2.**
  b) **Repetition Time (RT) is the time between 2 excitations pulses (time between two 90° RF pulses).**

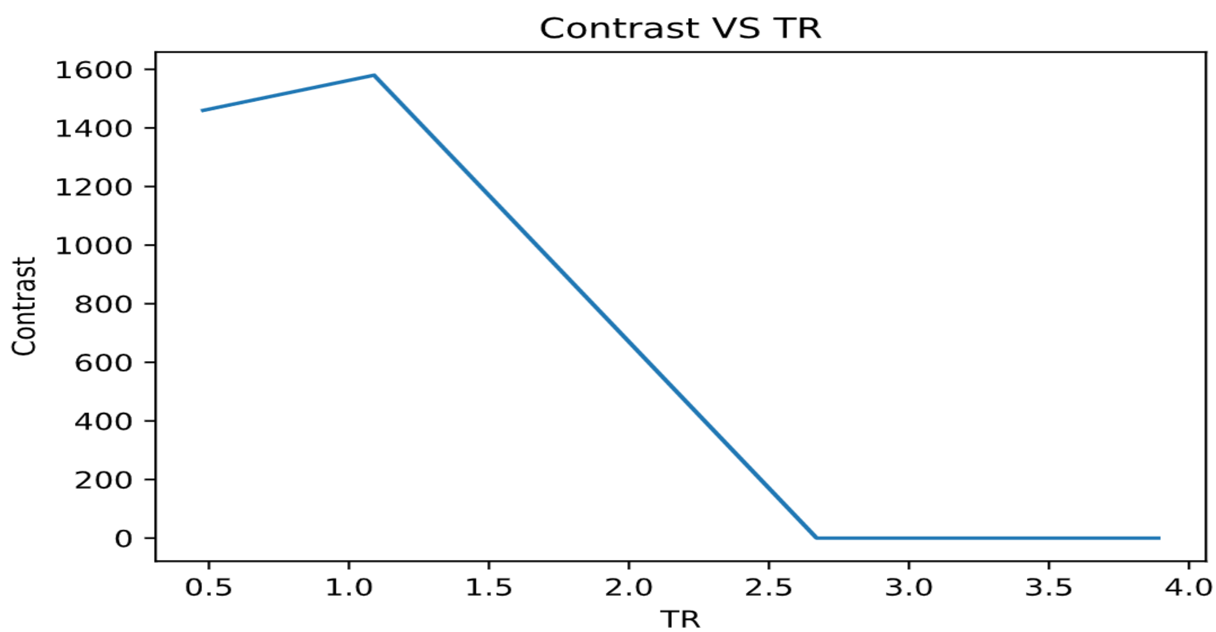
Question -3: What scanner parameters need to be changed to emphasize difference between tissue parameters?

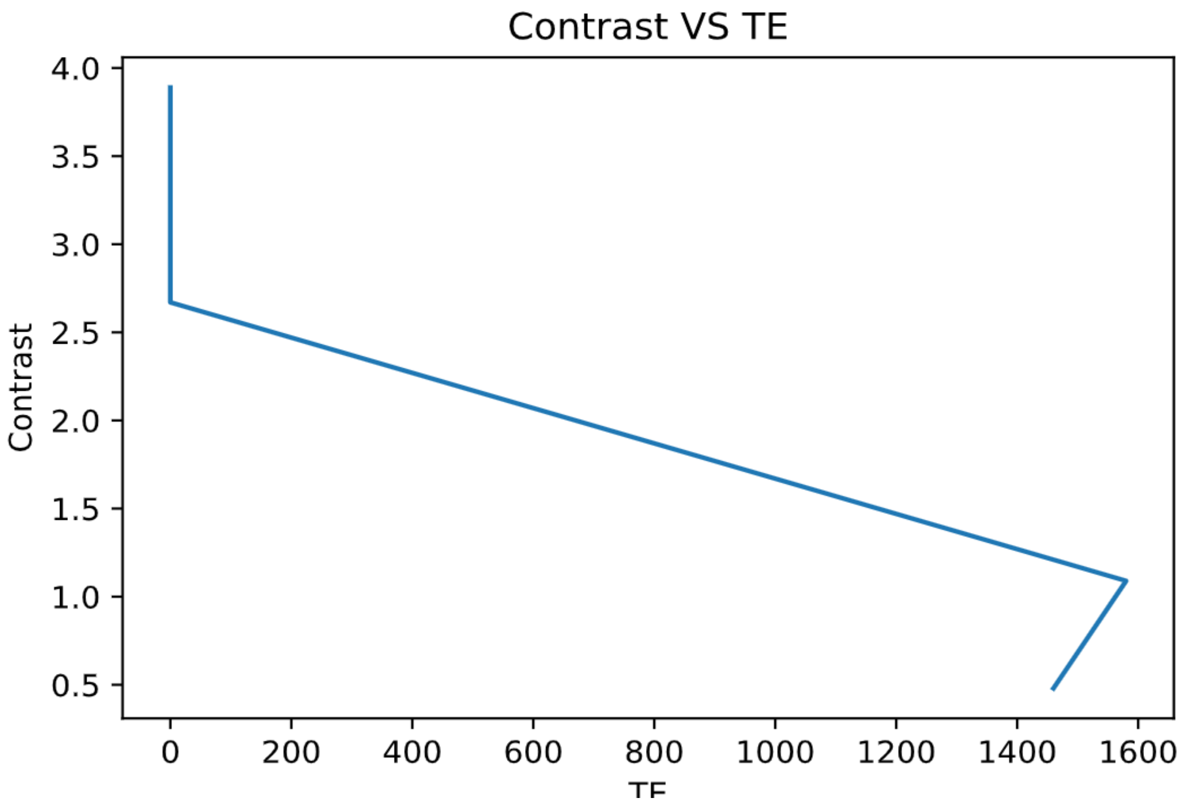
- **Field Offset parameter need to be changed to emphasize difference between tissue parameters.**

Question-4: In your code, with what type of structures you can assign parameters to different types of tissue?

- **In my code, I have created a trapezoidal virtual human using loop where the size can be increased just by changing number of loop required and it has 2D structure. So, any 2D structure type tissue can be used to assign parameters.**

Question 5: generate two graphs (1) Contrast vs. TR and (1) Contrast vs. TE





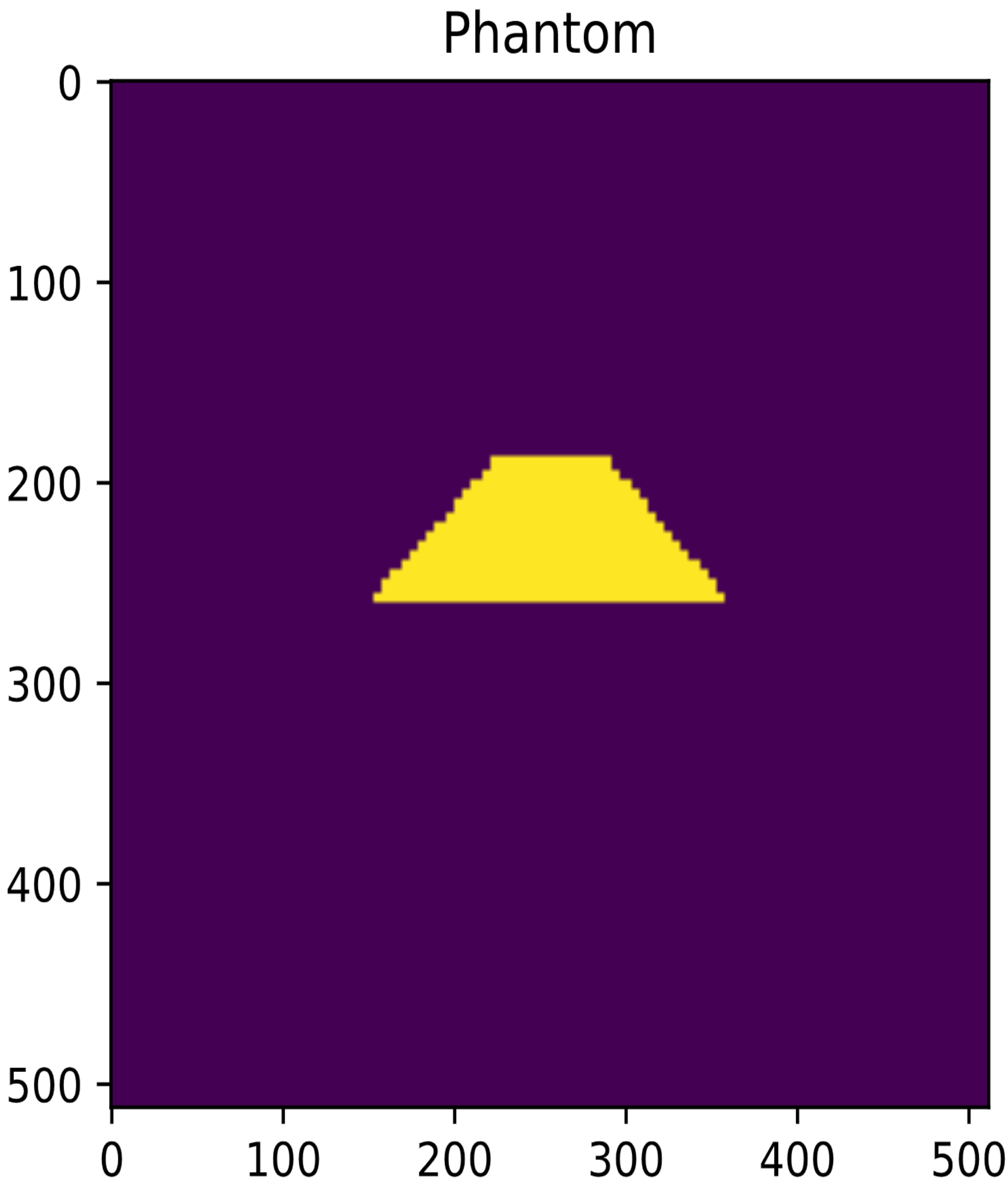
Input Values:

```
-   # Phantom Parameters
-   x = 512 # pixels
-   y = 512 # pixels
-   length = 10 # cm
-
-   TP = np.zeros(4)
-   TP[0] = 0.48 ## fat
-   TP[1] = 1.09 ## muscle
-   TP[2] = 2.67 ##skin
-   TP[3] = 3.89 ##bone
-
-   ## specific Sensor (m/sec)
-   SP = np.zeros(4)
-   SP[0] = 1460 ## Longitudinal
-   SP[1] = 1580 ## Transverse
-   SP[2] = 0000
-   SP[3] = 0000
```

Images for code used to create Phantom

```
[74]
# Generate Phantom and Display
    # Parameters:
        # (x,y) resolution
        # Length (real world)
        # TP Tissue Parameter values
        # SP Sensor Parameter values
def generate_phantom (x,y,length,TP, SP):

    # Create phantom matrix, U matrix, L matrix
    phantom = np.zeros((y,x), np.uint8) # phantom image
    U = np.zeros((y,x), np.float32) # Tissue matrix
    S = np.zeros((y,x), np.float32) # Sensor 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 * TP[0]
        S += struct_k *SP[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 Tissue to U matrix
    U[np.where(U == 0)] = TP[1]

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

    return phantom, U, S, L
```

Images from Phantom of 512*512 pixels resolution:



2D MRI image formed: