生醫影像導論

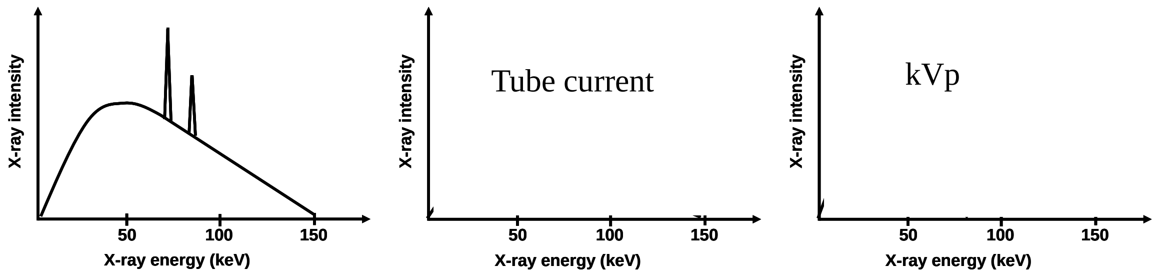
Introduction to Biomedical Imaging

(11020EE 441000)

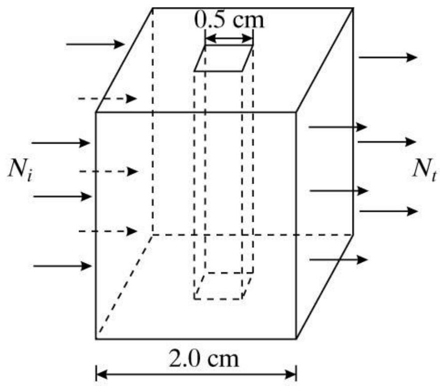
Homework #3: X-Ray Imaging

Due: 24:00, 06/05/2022

1. The left most figure below shows the intensity of X-rays produced from a source as a function of their energy (i.e., X-ray energy spectrum). With respect to the reference graph shown on the left, plot the corresponding X-ray energy spectrum once you increase the accelerating voltage (kVp) and tube current, respectively.



2. A slab of soft tissue with one blood vessel running in the middle is imaged under an X-ray imaging system, as shown in the following figure. For ease of computation, assume the tissue and the vessel both have squared-shaped cross-sections; the dimensions are shown in the figure. Assume that the X-ray source produces $N_i = 4 \times 10^6$ photons at either 15 keV or 40 keV, and the photons are uniformly shed upon the side of the tissue. The linear attenuation coefficients μ of the soft tissue, blood, and a radiographic contrast agent at two energy levels are given in the table below.



	Linear attenuation coefficient (cm^{-1})		
Energy (keV)	Soft tissue	Blood	Contrast agent
15	4.0	3.0	5.0
40	0.4	0.2	20

Ignoring photon noise, detector efficiency, beam divergence, Compton scattering, path length, and magnification effects,

(a) Determine the total number of exiting photons at the two energy levels, respectively. At which energy level are more photons absorbed.

(b) Calculate the local contrast $[(I_t-I_b)/I_b$, t: target, b: background] of the blood vessel (target) at each energy level. At which energy level is the local contrast of the blood vessel better?

(c) Suppose the contrast agent whose linear attenuation coefficient is given in the table were injected into the blood vessel. Would you expect there to be much difference in the local contrast at 15 keV after injection? How about at 40 keV? (No calculations, please, just mathematical reasoning)

(d) Tell the possible reason why the linear attenuation coefficient of the contrast agent is much larger at 40 keV than at 15 keV.

3. Please provide the definition of "dose" and "exposure" in X-ray imaging, including the unit, and provide the dose (with number and unit) commonly used in clinical situations.

4. Describe "Dual Energy Imaging" at least including the purpose and principles.

5. Please find out the spatial resolution of common X-ray imaging in μm, and the values of commonly used accelerating voltage (kVp) and tube current (mA or mAs), both of which I never mentioned in my lecture because I have no idea, either but I believe, both of which are body-type dependent.

Notice:

1. From quiz 3 to 5, please provide citation links if there are any.
2. 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.
3. Name your solution files "BioMedImg_HW3_StudentID.doc" and "BioMedImg_HW3_StudentID.m", and archive them as a single zip file: BioMedImg_HW3_StudentID.zip.
4. 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 HW3 06/02/2022
5. Please include "figures" and "reference sources" in your word file