BioE 1330 - Homework 3 – with answers

1. What's a "purely deterministic argument"? Give an example applying to image noise.

Ans. A purely deterministic argument is a parameter in the estimation or description of noise, that occurs independently of any imaging parameter, and at a specific time and location that cannot be predicted, but in a pattern in time described by a statistical distribution. Radioactive decay is a deterministic process.

2. The mean value is obtained by the integral of a weighted average (similar to the center of gravity), that is, the probability of a value times the value itself. Why don't we need to divide by the number of values to normalize the mean?

Ans. The integral is performed on a function with a total volume of 1. It is normalized before the calculation of the mean is performed.

3. Random distributions may have a Poisson distribution. If the distribution of an event is known, how can it be random?

It is random in the sense that any specific event cannot be predicted. It is a bounded chaotic process in that the accumulation of all discrete events is bounded by some probability distribution.

4. Signal to noise ratio is a function of the modulation transfer function (frequency response) and the noise power spectrum. Real MTF's roll off at the top end (i.e. loose high frequencies). He also said that the more high frequencies that are lost (i.e. the worse the MTF), the worse the signal to noise. Many types of noise occur only at high frequencies. How can SNR be worsened by an MTF that looses high frequencies?

Ans. The MTF describes the loss of frequency content within the signal after passing through the system. The attenuation of high frequencies represents loss of a portion of the signal. The "high frequency" sources of noise tend to be discrete random events occurring independent of the system, and are not attenuated by it. (I.e., high frequency noise adds in after the system attenuates the high end of the signal.)

5. Why might the diameter of the heart appear to be larger in a planar radiograph than in a CT scan?

Ans: Planar radiographs are subject to variable magnification depending on distance to the film when structures are projected onto the film.

6. How are gamma rays and x-rays different? How are they the same?

Ans: Difference: gamma rays are produced by radioactive decay, x-rays from electron interactions. Same: Both are high energy photons.

7. Signal to noise ratio is related to contrast and the rate at which signal is received, but why should it be related to area?

Ans: Larger objects are easier to see. Conversely, as the size of an object of interest shrinks, its contribution to the image is reduced relative to background noise levels. Basically a larger sample size give more reliable statistics.

8. The contingency table contains four conditions: true positives (identification of disease where it exists), true negatives (failure to ID disease where none exists), false positives (identification of disease where none exists), and false negatives (failure to ID disease where it exists. Place each of these terms on the appropriate location on the contingency table, identifying each cell by the letters a, b, c, and d as shown in the figure 3.14 in the book (p. 93) .

A given test for prostate cancer has the following values in a study: a=100, b=1, c=5, d=500. What is the sensitivity, specificity, and prevalence?

Ans: a: True positive, b: false negative, c: false positive, d: true negative. Sensitivity = a/(a+c) = .952, specificity = d/(b+d) = 99.8, prevalence = (a+c)/(a+b+c+d)= .173