Take Home Quiz 1: Winslow Lectures
Due Friday, October 11th, 11:59 pm.
Please submit a PDF (compiled LaTeX, exported Word Doc, etc.).

Question 1: Positive and Negative Predictive Values

A. The study of Liu et al "Data-driven discovery of a novel sepsis pre-shock state predicts impending septic shock in the ICU" investigated the problem of predicting those patients with sepsis who progress to septic shock. This study considered 15,932 patients with sepsis 3,507 of whom developed septic shock. The maximum sensitivity and specificity achieved in this study were 88 and 84% respectively. Average positive predictive value was 58%. The prevalence of septic shock is approximately 3 times lower in children than adults. If the predictive tool developed in the work of Liu et al were deployed in a pediatric ICU, what do you predict would be the average positive predictive value?

B. Negative predictive value is defined as the ratio of the number of true negative decisions to the total number of negative decisions (true and false). Average negative predictive value for the Liu algorithm when applied to adults in the ICU is 97%. If the predictive tool developed in the work of Liu et al were deployed in a pediatric ICU, what do you predict would be the average negative predictive value?

C. Implicit in parts A and B above is the assumption that a predictive algorithm developed for use in adults applies (un-modified) to children. However, this is likely not true. As pediatricians frequently say, "children are not small adults". Do some research to discover how the features used in the Liu algorithm might need to be modified if the algorithm is to be applied to children. Describe these changes.

Question 2: Maximum Likelihood Estimation

Children who have had surgery to correct congenital heart defects are at high risk for arrhythmias post-surgery. Initially, these arrhythmias are transient manifesting in single heart beats rather than being sustained. Suppose we have developed an algorithm that operates on ECG waveforms to detect these arrhythmias and does so reliably. We want to count the number of arrhythmias per unit time and alert caregivers if the arrhythmia rate exceeds a threshold value. To do this we need to estimate the arrhythmia rate. Assume that the number of arrhythmias per unit time is distributed as a Poisson random variable. That is, in a time-interval of width Δt Sec, the probability of observing N arrhythmias is:

$$P(N=n)=\frac{(\lambda\Delta t)^n}{n!}e^{-\lambda\Delta t}$$

where λ is the rate of the Poisson process (it is the arrhythmia rate per Sec). Assume Δt is 1 Sec, thereby assuring that only zero or one arrhythmia event occurs within this time. Assume that each minute, we have a record of 60 0’s and 1’s indicating whether an arrythmia event did (1) or did not (0) occur during each interval of one second duration. Derive the maximum likelihood estimate of the arrhythmia rate for each minute.