Neuroinformatics Exercise
Fall 2017

Exercise E4

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Instructions: (10 points) Solve the following problems. Write clearly and use same symbols as used in the lecture. Add comments, explanations or questions to your solution if necessary.
Solutions to exercise **1** is to be submitted as physical copies in groups of three or four. Please label each page you hand in **clearly** and **carefully** with the name of each group member and their student ID.
Please staple all of your sheets.
Deadline for this exercise sheet is: **30.11.2017**

(10^{pts}) **1.** Let's look at a single spiketrain with spikes described by a binary process (i.e. a 0 means no spike, 1 means spike). We observe N bins in an interval between 0 and T, for each bin we record whether or not a spike occurred. The figure below is an example of how your data might look like after recording $N = 20$ bins. For each of the problems below, give the general solution for any spike train and N bins. Do not use results from the lecture.

10 pts

Figure 1: An example spike train after observing $N = 20$ bins.

(a) Use the Bernoulli model and assume i.i.d. bins to calculate the maximum likelihood (ML) estimate of the probability of a spike occurring in a bin.

(b) Rethink your approach and remember that we derived the binomial model in the lecture as well. Derive the ML estimator for μ (or p, the probability of a spike occurring) for the same problem using the binomial distribution.

(c) The Poisson distribution is often used to model spike trains. Here, however, we do not consider any bin size, but instead model how many spikes k occur in a fixed time interval between 0 and T. Derive a ML estimate for λ, after having observed k spikes in an interval.

2. ADVANCED Show that the sum of two independent Poisson random variables $X \sim \text{Poisson}(X = x|\lambda)$ and $Y \sim \text{Poisson}(Y = y|\mu)$ is again a Poisson distributed random variable $Z \sim \text{Poisson}(Z = z|\lambda + \mu)$

3. You have decided that a binary experiment you observe is best modeled by a Bernoulli distribution. Previously you have measured mean 0.3 from which you can also calculate the variance. The question you ask yourself is this: In the next 100 trials, what is the probability that I get 40 or less successes? Try and approach your problem using the Central Limit Theorem presented in the lecture.