

Stat 5102 (Geyer) Spring 2016  
Homework Assignment 6  
Due Wednesday, October 26, 2016

Solve each problem. Explain your reasoning. No credit for answers with no explanation. If the problem is a proof, then you need words as well as formulas. Explain why your formulas follow one from another.

**6-1.** Suppose  $X_1, X_2, \dots, X_n$  are IID  $\text{Exp}(\lambda)$ . Find the likelihood function and log likelihood function.

**6-2.** Suppose  $X_1, X_2, \dots, X_n$  are IID  $\text{Geo}(p)$ . Find the likelihood function and log likelihood function.

**6-3.** Suppose  $X_1, X_2, \dots, X_n$  are IID  $\text{Cauchy}(\mu, \sigma)$ , where both  $\mu$  and  $\sigma$  are unknown parameters. Find the likelihood function and log likelihood function.

**6-4.** Suppose  $X_1, X_2, \dots, X_n$  are IID  $\text{Laplace}(\mu, \sigma)$ , where both  $\mu$  and  $\sigma$  are unknown parameters. Find the likelihood function and log likelihood function.

**6-5.** Suppose  $X_1, \dots, X_n$  are IID  $\text{Exp}(\theta)$  and  $Y_1, \dots, Y_n$  are IID  $\text{Exp}(1/\theta)$  and the  $X$ 's and  $Y$ 's are independent of each other. Find the likelihood function and log likelihood function.

**6-6.** Suppose  $X_1, X_2, \dots, X_n$  are IID with PDF

$$f_\theta(x) = (\theta - 1)x^{-\theta}, \quad 1 < x < \infty,$$

where  $\theta > 1$  is an unknown parameter. Find the likelihood function and log likelihood function.

**6-7.** Find the first and second derivatives of the log likelihood function

(a) for problem 6-1.

(b) for problem 6-2.

(c) for problem 6-3, considering  $\mu$  the unknown parameter and  $\sigma$  known.

(d) for problem 6-5.

(e) for problem 6-6.

**6-8.** Find the Fisher information

- (a) for problem 6-1.
- (b) for problem 6-2.
- (c) for problem 6-5.
- (d) for problem 6-6.

**6-9.** For the setup of Problem 6-1

- (a) Find the MLE.
- (b) Show that your MLE is at least a local maximizer of the log likelihood.
- (c) If the log likelihood is strictly concave, show that it is.
- (d) Find the asymptotic distribution of your MLE.
- (e) Show that your MLE is the same as a method of moments estimator we derived earlier, and the asymptotic distribution obtained in part (d) is the same as the asymptotic distribution derived earlier via the delta method.
- (f) Give an asymptotic 95% confidence interval for the parameter based on the asymptotic distribution of the MLE.

**6-10.** For the setup of Problem 6-2

- (a) Find the MLE.
- (b) Show that your MLE is at least a local maximizer of the log likelihood.
- (c) If the log likelihood is strictly concave, show that it is.
- (d) Find the asymptotic distribution of your MLE.
- (e) Show that your MLE is the same as a method of moments estimator we derived earlier, and the asymptotic distribution obtained in part (d) is the same as the asymptotic distribution derived earlier via the delta method.
- (f) Give an asymptotic 95% confidence interval for the parameter based on the asymptotic distribution of the MLE.

**6-11.** For the setup of Problem 6-5

- (a) Find the MLE.
- (b) Show that your MLE is at least a local maximizer of the log likelihood.
- (c) If the log likelihood is strictly concave, show that it is.
- (d) Find the asymptotic distribution of your MLE.
- (e) Give an asymptotic 95% confidence interval for the parameter based on the asymptotic distribution of the MLE.

**6-12.** For the setup of Problem 6-6

- (a) Find the MLE.
- (b) Show that your MLE is at least a local maximizer of the log likelihood.
- (c) If the log likelihood is strictly concave, show that it is.
- (d) Find the asymptotic distribution of your MLE.
- (e) Give an asymptotic 95% confidence interval for the parameter based on the asymptotic distribution of the MLE.

**6-13.** For the setup of Problem 6-4, suppose that  $\mu$  is the unknown parameter and  $\sigma$  is known. Show that the sample median is an MLE. Note that the log likelihood is not everywhere differentiable, so this problem cannot be done by setting the first derivative equal to zero and solving. You need a different argument. **Hint:** Consider properties of the sample median.

**6-14.** Suppose  $X$  is  $\text{Poi}(\mu)$ . Find the MLE. Show that it is the unique global maximizer of the likelihood. **Caution:** In this problem the data are  $X$ . There is no  $X_1, X_2, \dots$

**6-15.** Suppose  $X$  is  $\text{Poi}(\mu)$ . Suppose we are interested in the parameter  $p = e^{-\mu}$ , which is  $\Pr(X = 0)$ .

- (a) Find the MLE for  $p$ .
- (b) Find the Fisher information for  $p$ .
- (c) Find the asymptotic distribution of your MLE.
- (d) Give an asymptotic 95% confidence interval for the parameter based on the asymptotic distribution of the MLE.