STA261 Lecture 6 — 2017-07-26

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Last edited: 2017-07-26 19:01

unfinished business from Lecture 5

Theorem 5.2 had a typo in its statement

Theorem 5.2 $\mathcal{I}(\theta) = \mathrm{Var}(S(\theta))$ and $\mathcal{I}(\theta) = -E\left(\frac{\partial^2}{\partial\theta^2} \log L(\theta; \mathbf{X})\right)$

The proof was fine.

Proposition 5.4

The definition of information uses a sample:

$$\mathcal{I}(\theta) = \mathcal{I}(\theta; \mathbf{X}) = E\left(\left(\frac{\partial}{\partial\theta} \log L(\theta; \mathbf{X})\right)^2\right)$$

Rice defines something also called $I(\theta)$ which is for a single random variable X

Proposition 5.4a $\mathcal{I}(\theta) = nI(\theta)$.

Proposition 5.4 Under suitable conditions, $\sqrt{\mathcal{I}(\theta)}(\hat{\theta} - \theta) = \sqrt{nI(\theta)}(\hat{\theta} - \theta)$ converges (in distribution) to a standard normal distrubution.

a few MLE extras

Asymptotic normality implies (under the same “regularity”) conditions asymptotic unbiasedness.

In many cases $\text{Var}\left(\hat{\theta}\right) = \mathcal{I}(\theta)^{-1}$. For large samples we can still often use $\text{Var}\left(\hat{\theta}\right) \approx \mathcal{I}(\theta)^{-1}$.

example where things fall apart

Example 6.0: Consider Uniform$[0, \theta]$. Which nice properties does $\hat{\theta}$ have?

summary of MLE facts, proven and not proven

Under suitable conditions:

- smoothness of density
- non-zero part of density does not depend on θ

an MLE is:

- consistent (not proven)
- asymptotically normal (proven) (and therefore asymptotically unbiased)
- invariant, $\widehat{h(\theta)} = h(\hat{\theta})$ (not proven - tedious in general but very easy when, say h is differentiable and monotone increasing. Try it!)

the class of unbiased estimators

a possible “gold standard” for estimators

If we restrict ourselves to unbiased estimators only, a plausible standard would be to choose the one that has the smallest variance.

The purpose of the next part of the course is to see when it is possible to find such estimators.

This will cause us to define and investigate the notion of “sufficiency”. But not yet.

a lower bound on the variance of an unbiased estimator

If you somehow knew the lowest possible variance among unbiased estimators, and you have an unbiased estimator with that variance, then you're done.

Reminder 6.1: The correlation coefficient ρ is a property of a joint distribution, and $-1 \leqslant \rho \leqslant 1$.

Theorem 6.2: Suppose $X_1, \ldots, X_n$ is i.i.d. with density $f(x;\theta)$ and $T = t(X_1, \ldots, X_n)$ is unbiased for θ. Then (under the usual conditions on f):

$$\mathrm{Var}(T) \geqslant \frac{1}{\mathcal{I}(\theta)}$$

This is called the "Cramer-Rao" lower bound.

examples

Example 6.3: $N(\mu, 1)$

Example 6.4: Poisson(λ)

Example 6.5: Uniform$[0, \theta]$