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Lecture 4: Parametric Estimation

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9. Conservative Bound Confidence Interval using a Conservative Bound

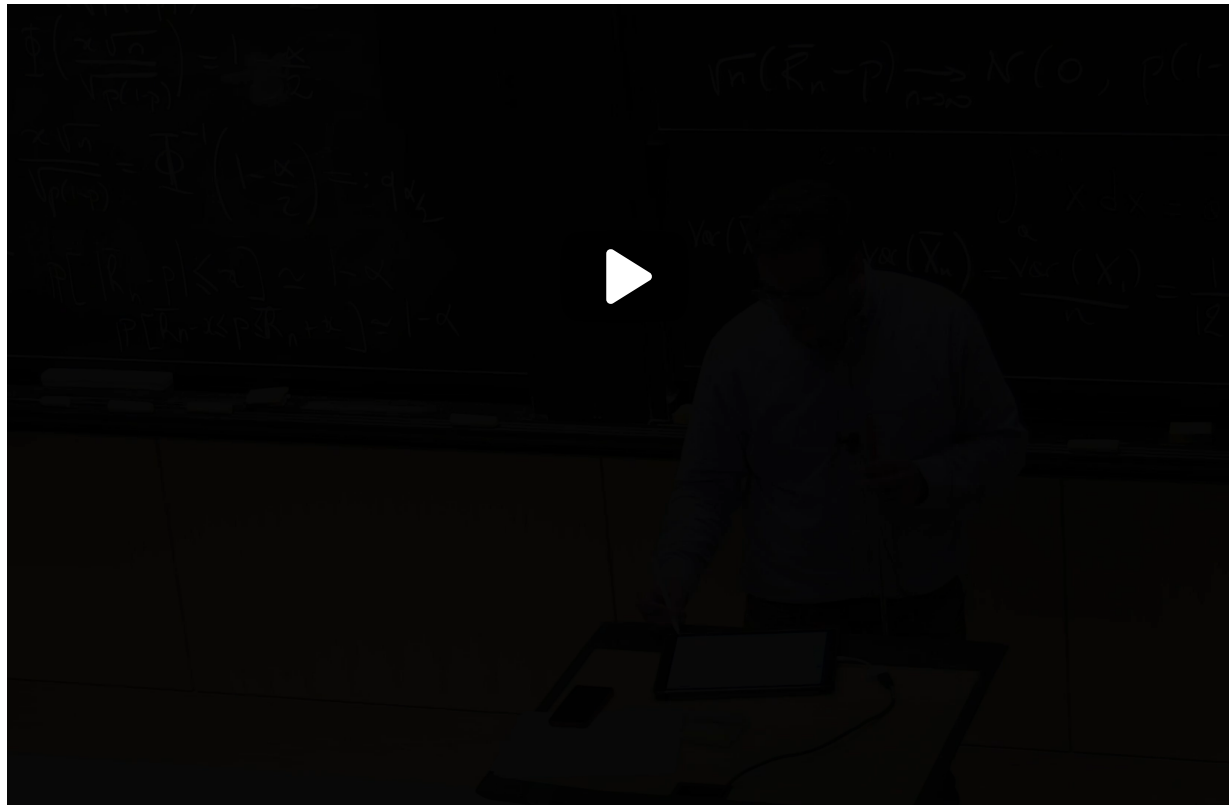
And I already knew that this was equal to $1 - \alpha$

when I kept $p - 1 - p$.

OK.

So first way to do it, if you have an upper bound,

so if your bounds depend on your



unknown p ,

just try to find something which contains
all the possible values of your unknown
 θ in general,

just get something which contains
all the possible values that it can take

and make it just more conservative but
no more

than what's needed.

First solution.



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Conservative bound

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As in the video above, let $R_1, \dots, R_n \stackrel{iid}{\sim} \text{Ber}(p)$ for some unknown parameter p . We estimate p using the estimator $\hat{p} = \bar{R}_n = \frac{1}{n} \sum_{i=1}^n R_i$.

Recall that by the central limit theorem, for any p , ($0 < p < 1$):

$$\lim_{n \rightarrow \infty} \mathbf{P} \left(\left| \sqrt{n} \frac{\bar{R}_n - p}{\sigma_p} \right| < q_{\alpha/2} \right) = \lim_{n \rightarrow \infty} \mathbf{P} \left(\bar{R}_n - q_{\alpha/2} \frac{\sigma_p}{\sqrt{n}} < p < \bar{R}_n + q_{\alpha/2} \frac{\sigma_p}{\sqrt{n}} \right) = 1 - \alpha$$

where $\sigma_p = \sqrt{p(1-p)}$.

To construct a confidence interval, we need to replace σ_p above by a number c that does not depend on the unknown parameter p .

Which of the following conditions on c will guarantee that for all p in $(0, 1)$,

$$\lim_{n \rightarrow \infty} \mathbf{P} \left(\left| \sqrt{n} \frac{\bar{R}_n - p}{c} \right| < q_{\alpha/2} \right) \geq 1 - \alpha?$$

(Choose all that apply.)

☒ $c \geq \sigma_p$ for **all** p

☐ $c \geq \sigma_p$ for **some** p

☒ $c = \max_p (\sigma_p)$

☐ $c \leq \sigma_p$ for **all** p

☐ $c \leq \sigma_p$ for **some** p

☐ $c = \min_p (\sigma_p)$



Solution:

Any number c such that

$$\left(\bar{R}_n - q_{\alpha/2} \frac{c}{\sqrt{n}}, \bar{R}_n + q_{\alpha/2} \frac{c}{\sqrt{n}} \right) \supseteq \left(\bar{R}_n - q_{\alpha/2} \frac{\sigma_p}{\sqrt{n}}, \bar{R}_n + q_{\alpha/2} \frac{\sigma_p}{\sqrt{n}} \right) \quad \text{for all } p$$

will give the required probability for all p . Hence any $c \geq \max_p (\sigma_p)$ works.

Note: In this example, since $\sigma_p = \sqrt{p(1-p)}$, $\max_p(\sigma_p) = \max_p(\sqrt{p(1-p)}) = 1/2$.

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i Answers are displayed within the problem

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