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Now we develop the confidence interval for a probability estimates. This confidence interval is derived by re-writing the \hat{p}_{event} probability estimate given in Equation (15.14) in terms of the mean of an indicator function x :

- $x = 0$: when the event did not occur for an instance
- $x = 1$: when the event did occur for an instance

With this indicator function, then we can prove that the sample mean of x is equal to \hat{p}_{event} :

$$\bar{x} = \frac{1}{N} \sum_{i=0}^{N-1} x_i = \frac{N_{\text{event}}}{N} = \hat{p}_{\text{event}}$$

(15.24)

Thus, we can use the properties of the sample mean estimate to derive the properties of the \hat{p}_{event} estimate. Specifically,

- Since \bar{x} is an unbiased estimate of μ_x , then \hat{p}_{event} is an unbiased estimate of p_{event} .

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- With some algebraic manipulations, the standard error for \hat{p}_{event} can be shown to be:



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$$\sigma_{\hat{p}}^2 \equiv E[(\hat{p}_{\text{event}} - p_{\text{event}})^2] = \frac{p_{\text{event}} (1 - p_{\text{event}})}{N}$$

(15.25)

- In practice, the standard error is estimated by assuming $p_{\text{event}} \approx \hat{p}_{\text{event}}$, such that,

$$\sigma_{\hat{p}}^2 \approx \frac{\hat{p}_{\text{event}} (1 - \hat{p}_{\text{event}})}{N}$$

(15.26)

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- A 95% confidence interval for the probability estimate is then,

$$\hat{p}_{\text{event}} - 1.96\sigma_{\hat{p}} < p_{\text{event}} < \hat{p}_{\text{event}} + 1.96\sigma_{\hat{p}}$$

(15.27)

The following video discusses this confidence interval for a probability estimate.

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The Python script used in this video (and several others) is available [here](#).

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Video on confidence intervals for probability estimates

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Video

intervals for our probability
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