

Ex. 7.4 Consider the in-sample prediction error (7.18) and the training error $\overline{\text{err}}$ in the case of squared-error loss:

$$\begin{aligned}\text{Err}_{\text{in}} &= \frac{1}{N} \sum_{i=1}^N \mathbb{E}_{Y^0} (Y_i^0 - \hat{f}(x_i))^2 \\ \overline{\text{err}} &= \frac{1}{N} \sum_{i=1}^N (y_i - \hat{f}(x_i))^2.\end{aligned}$$

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Add and subtract $f(x_i)$ and $\mathbb{E}\hat{f}(x_i)$ in each expression and expand. Hence establish that the average optimism in the training error is

$$\frac{2}{N} \sum_{i=1}^N \text{Cov}(\hat{y}_i, y_i),$$

as given in (7.21).