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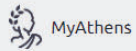
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2.2. BIAS AND VARIANCE

Consider performing the following experiment. We first collect a random sample \mathcal{D} of N independently drawn patterns from the distribution $p(\mathbf{x}, y)$, and then measure the *sample error/training error/approximation error* from Eqn (2.4), using loss function (2.5) for classification problem or (2.6) for regression problem. Let us denote the approximation error based on data sample \mathcal{D} and hypothesis h as 'error $_{\mathcal{D}}[h]$ '. If we repeat the experiment several times, each time drawing a different sample $(\mathbf{x}^{(j)}, y^{(j)})$ of size N , we would expect to see different values of error $_{\mathcal{D}}[h]$, on the basis of the random differences in the way the different samples of size N are made up. We say in such cases that error $_{\mathcal{D}_j}[h]$, the result of the j^{th} experiment, is a *random variable*.

Imagine that we were to run K such experiments, measuring the random variables error $_{\mathcal{D}_j}[h]; j = 1, 2, \dots, K$. The average over the K experiments:

$$\text{error}_{\mathcal{D}}[h] = \mathbb{E}_{\mathcal{D}}\{\text{error}_{\mathcal{D}_j}[h]\}$$

(2.7)

where $\mathbb{E}_{\mathcal{D}}\{\cdot\}$ denotes the expectation or ensemble average.

Bias and variance are most easily understood in the context of regression (numeric prediction). It is convenient to consider the particular case of a hypothesis function trained using the risk function (2.4), although our conclusions will be much more general.

Let us suppose that there is a true (yet unknown) function $f(\mathbf{x})$ possessing a continuous-valued output v with

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