

## **$k$ -fold Cross Validation**

$k$ -fold cross validation is a common technique for estimating the performance of a classifier. Given a set of  $m$  training examples, a single run of  $k$ -fold cross validation proceeds as follows:

1. Arrange the training examples in a random order.
2. Divide the training examples into  $k$  folds. ( $k$  chunks of approximately  $m/k$  examples each.)
3. For  $i = 1, \dots, k$ :
  - Train the classifier using all the examples that do not belong to Fold  $i$ .
  - Test the classifier on all the examples in Fold  $i$ .
  - Compute  $n_i$ , the number of examples in Fold  $i$  that were wrongly classified.
4. Return the following estimate to the classifier error:

$$E = \frac{\sum_{i=1}^k n_i}{m}$$

To obtain an accurate estimate to the accuracy of a classifier,  $k$ -fold cross validation is run several times, each with a different random arrangement in Step 1. Let  $E_1, \dots, E_t$  be the accuracy estimates obtained in  $t$  runs. Define:

$$e = \frac{\sum_{j=1}^t E_j}{t}, \quad V = \frac{\sum_{j=1}^t (E_j - e)^2}{t - 1}, \quad \sigma = \sqrt{V}$$

The estimate for the algorithm performance is an error of  $e$  with standard-deviation of  $\sigma$ .