# Naïve Bayes Classifier

# Objective

Objective

Implement the fundamental learning algorithm Naive Bayes

# Naïve Bayes Classifier

- The "naive" *conditional independence* assumption: each feature is (conditionally) independent of every other feature, given the label, i.e., $p(x_i | \{x_j \text{ for any } j \neq i\}, y) = p(x_i | y)$

- How does this assumption simplify the problem?
  - Consider the previous example again: d-dimensional binary features, and y is also binary.
  - How many probabilities do we need to estimate now?

$p(\mathbf{x} | y) = p(x_1, x_2, \ldots, x_d | y) = \ldots$

# Naïve Bayesian Classifier (cont'd)

- The naïve Bayes classifier: the predicted label is given by

$$\hat{y} = \underset{y}{\operatorname{argmax}}\, P(\mathrm{y}) \prod_{i=1}^{d} p(\mathrm{x}_i|y)$$

- "Parameters" of the classifier:
  - $P(\mathrm{y})$
  - $p(\mathrm{x}_i|\mathrm{y})$ for all i, y

# Naïve Bayesian Classifier (cont'd)

E.g., estimating the "parameters" of the classifier

- $P(y)$ & $p(x_i|y)$ for all i, y -

for the following familiar example

# Discrete Feature Example

- $\mathbf{x} = \langle x_1, x_2, \ldots, x_d \rangle$ where each $x_i$ can take only a finite number of values from $\{v_1, v_2, \ldots, v_m\}$:

- In this case, the "parameters" of the classifier are
  - $P(y)$
  - $P(x_i = v_k | y)$, for all i, k, and y

- Given: A training set of $n$ labelled samples $\langle x^{(i)}, y^{(i)} \rangle$, $i=1, \ldots, n$

  ➔ How to estimate the model parameters?

# Discrete Feature Example (cont'd)

- Given: A training set of $n$ labelled samples $\langle x^{(i)}, y^{(i)} \rangle$, $i=1, \ldots, n$

  ➔ How to estimate the model parameters?

$$P(y) =$$

$$P(x_i = v_k \mid y) =$$

- These are in fact the MLE solutions for the corresponding parameters.