

CS 383: Machine Learning

Prof Adam Poliak

Fall 2024

10/01/2024

Lecture 11

Announcements

HW03 is due Tuesday night

- **Reading quiz: Thursday**
 - Duame 9.3 (2 pages)

Updated schedule

No lecture on Thursday

No lecture Wednesday 10/09

Lecture tomorrow Wed 10/02

HW03 polynomial regression due tonight

HW04 naive Bayes due Tuesday 10/08 (it'll be a shorter assignment)

Midterm 1 on Thursday after fall break

Reading Quiz #4

1. How would you say $P(A, B)$ in words?
2. Based on class on Tuesday, what is Bayes rule?

$$P(A, B) =$$

3. What is the Naive Bayes assumption? (circle one)
 - (a) The label and the features are independent given the model
 - (b) Features are independent given the label
 - (c) Training examples are independent given their labels
4. If I want to predict the label (y) of an example based on its features (\vec{x}), which of the following expressions would I want to compute? (circle the best one)
 - (a) $p(\vec{x}, y)$
 - (b) $p(\vec{x} \mid y)$
 - (c) $p(y \mid \vec{x})$

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$$P(A, B) = \mathbf{P(A) P(B | A)} \quad \text{or} \quad \mathbf{P(B) P(A | B)}$$

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Outline

Naive Bayes

Confusion Matrix

Components of a Bayes Model

Identify the evidence, prior, posterior, and likelihood in the equation below

$$p(y = k|\mathbf{x}) = \frac{p(y = k)p(\mathbf{x}|y = k)}{p(\mathbf{x})}$$

Components of a Bayes Model

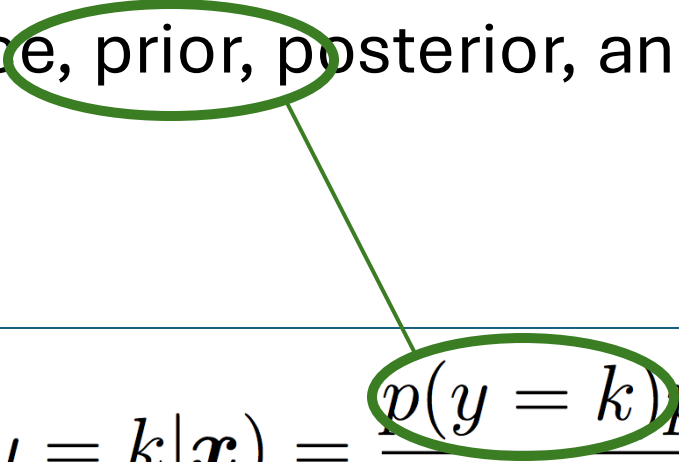
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Evidence: this is the data (features) we observe, which we think will help us predict the outcome we're interested in

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Prior: without seeing any evidence (data), what is our prior believe about each outcome (intuition: what is the outcome in the population as a whole?)

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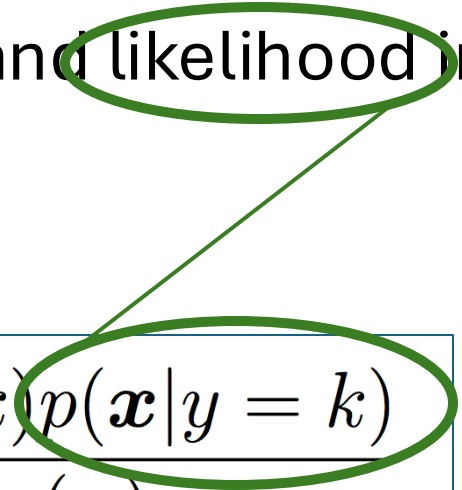
Identify the evidence, prior, **posterior**, and likelihood in the equation below

$$p(y = k | \mathbf{x}) = \frac{p(y = k)p(\mathbf{x} | y = k)}{p(\mathbf{x})}$$

Posterior: this is the quantity we are actually interested in.
Given the evidence, what is the probability of the outcome?

Components of a Bayes Model

Identify the evidence, prior, posterior, and likelihood in the equation below

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Likelihood: given an outcome, what is the probability of observing this set of features?

Naive Bayes Example

	Cat	Documents
Training	-	just plain boring
	-	entirely predictable and lacks energy
	-	no surprises and very few laughs
	+	very powerful
	+	the most fun film of the summer

Test: powerful very fun

$$p(+) = ?$$

$$p(-) = ?$$

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$$p(-)=\frac{p(predictable|-)p(with|-)p(no|-)p(fun|-)p(-)}{p(predictable)p(with)p(no)p(fun)}$$

Laplacian Smoothing

$$\hat{P}(w_i|c) = \frac{\textit{count}(w_i, c) + 1}{\sum_{w \in V} (\textit{count}(w, c) + 1)} = \frac{\textit{count}(w_i, c) + 1}{(\sum_{w \in V} \textit{count}(w, c)) + |V|}$$

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Logistic Regression

Linear regression for classification

Case Study: you need to identify the medical condition of a patient in the emergency room on the basis of their symptoms.

Possible conditions (y) are:

- Stroke
- Drug overdose
- Epileptic seizure

- 1) If you were forced to use linear regression for this problem, how could you encode y to make it real-valued?
- 2) What issues arise with making y real-valued?
- 3) What if you just had two outcomes (i.e. stroke and drug overdose) -- why is linear regression still not a good choice?

Linear regression for classification

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You could choose stroke=0, drug overdose=1, epileptic seizure=2 (or some permutation)

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Assumes some *ordering* of the outcomes that is probably not there!

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The range of a linear function (i.e. y values) is $[-\infty, \infty]$, but we want $[0, 1]$