CSIS3764 Data Science

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Machine Learning

Naive Bayes

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Bayes Theorem

- $P(A|B) = \frac{P(B|A)P(A)}{P(B)}$
- A Naive Bayes classifier is a probabilistic machine learning model that's used for classification task
  - Sentiment analysis
  - Spam filtering
  - Recommendation systems

Spam Filtering

- 12 Emails
  - 8 Normal
  - 4 Spam
- Words that occur in emails
  - Hello
  - Sally
  - Food
  - Lotto

Frequency of words

- Normal emails
  - Hello: 8 -> P(Hello|Normal) = 0.47
  - Sally: 5 -> P(Sally|Normal) = 0.29
  - Food: 3 - > P(Food|Normal) = 0.18
  - Price: 1 -> P(Price|Normal) = 0.06
- Spam emails
  - Hello: 2 -> P(Hello|Spam) = 0.29
  - Sally: 1 -> P(Sally|Spam) = 0.14
  - Food: 0 -> P(Food|Spam) = 0
  - Price: 4 -> P(Price|Spam) = 0.57

Example: “Hello Sally”

- Probability any message is normal
  - P(Normal) = 8/12 = 0.67
- Probability “Hello” and “Sally” is normal
  - P(Normal) x P(Hello|Normal) x P(Sally|Normal)

    0.67 x 0.47 x 0.29 = 0.09
- Probability any message is spam
  - P(Spam) = 4/12 = 0.33
- Probability “Hello” and “Sally” is spam
  - P(Spam) x P(Hello|Spam) x P(Sally|Spam)

    0.33 x 0.29 x 0.14 = 0.01
- **Message is Normal**

Example: “Food Price Price Price”

- Probability any message is normal
  - P(Normal) = 8/12 = 0.67
- Probability “Food” and “Price^4” is normal
  - P(Normal) x P(Food|Normal) x P(Price|Normal)^4

    0.67 x 0.18 x 0.06^4 = 0.000002
- Probability any message is spam
  - P(Spam) = 4/12 = 0.33
- Probability “Food” and “Price^4” is spam
  - P(Spam) x P(Food|Spam) x P(Price|Spam)^4

    0.33 x 0 x 0.57 = 0
- ?

Frequency Adjustment of words

- Normal emails
  - Hello: 9 -> P(Hello|Normal) = 0.43
  - Sally: 6 -> P(Sally|Normal) = 0.29
  - Food: 4 - > P(Food|Normal) = 0.19
  - Price: 2 -> P(Price|Normal) = 0.10
- Spam emails
  - Hello: 3 -> P(Hello|Spam) = 0.27
  - Sally: 2 -> P(Sally|Spam) = 0.18
  - Food: 1 -> P(Food|Spam) = 0.09
  - Price: 5 -> P(Price|Spam) = 0.45

Example: “Food Price Price Price”

- Probability any message is normal
  - P(Normal) = 8/12 = 0.67
- Probability “Food” and “Price^4” is normal
  - P(Normal) x P(Food|Normal) x P(Price|Normal)^4

    0.67 x 0.19 x 0.10^4 = 0.00001
- Probability any message is spam
  - P(Spam) = 4/12 = 0.33
- Probability “Food” and “Price^4” is spam
  - P(Spam) x P(Food|Spam) x P(Price|Spam)^4

    0.33 x 0.09 x 0.45 = 0.00122
- **Message is Spam**