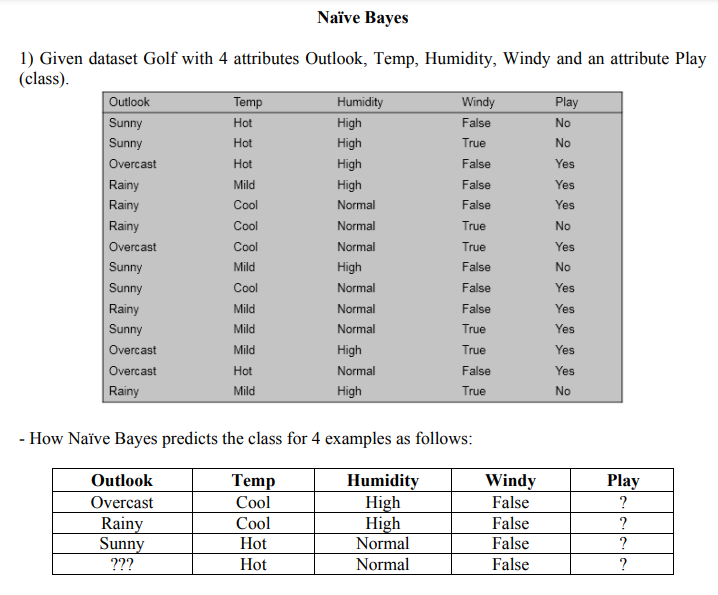
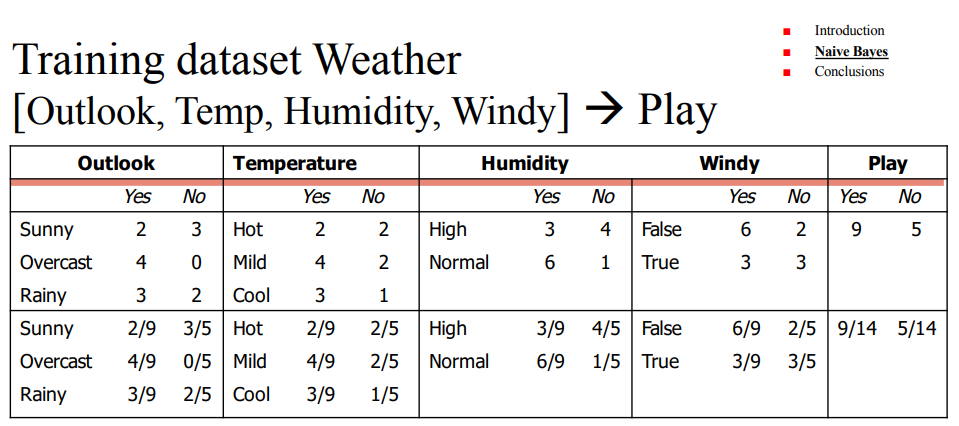
Name: Truong Dang Truc Lam ID: B2111933 Class: CT205H - M04

# Naive Bayes





Example 1:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Outlook | Temp | Humidity | Windy | Play |
| Overcast | Cool | High | False | ? |

In Example 1, we have to use Laplace Estimator to avoid zero probabilities.

For Play = Yes:

* P(Outlook=Overcast ∣ Play=Yes) = (4+1)/(9+3) = 5/12
* P(Temp=Cool ∣ Play=Yes) = (3+1)/(9+3) = 4/12 = 1/3
* P(Humidity=High ∣ Play=Yes) = (3+1)/(9+2) = 4/11
* P(Windy=False ∣ Play=Yes) = (6+1)/(9+2) = 7/11
* P(Play=Yes) = (9+1)/(14+2) = 10/16 = 5/8

P(Play=Yes | E)

= P(Play=Yes ∣ Outlook=Overcast,Temp=Cool,Humidity=High,Windy=False)

= P(Outlook=Overcast ∣ Play=Yes) \* P(Temp=Cool ∣ Play=Yes) \*  
P(Humidity=High ∣ Play=Yes) \* P(Windy=False ∣ Play=Yes) \* P(Play=Yes) / P(E)

= 5/12 \* 1/3 \* 4/11 \* 7/11 \* 5/8 / P(E) = 0.0201 / P(E)

For Play = No:

* P(Outlook=Overcast ∣ Play=No) = (0+1)/(5+3) = 1/8
* P(Temp=Cool ∣ Play=No) = (1+1)/(5+3) = 2/8 = 1/4
* P(Humidity=High ∣ Play=No) = (4+1)/(5+2) = 5/7
* P(Windy=False ∣ Play=No) = (2+1)/(5+2) = 3/7
* P(Play=No) = (5+1)/(14+2) = 6/16 = 3/8

P(Play=No | E)

= P(Play=No ∣ Outlook=Overcast,Temp=Cool,Humidity=High,Windy=False)

= P(Outlook=Overcast ∣ Play=No) \* P(Temp=Cool ∣ Play=No) \*

P(Humidity=High ∣ Play=No) \* P(Windy=False ∣ Play=No) \* P(Play=No) / P(E)

= 1/8 \* 1/4 \* 5/7 \* 3/7 \* 3/8 / P(E) = 0.0036 / P(E)

Conversion into a probability by normalization:

* P(Play=Yes | E) = 0.0201 / (0.0201 + 0.0036) = 0.848
* P(Play=No | E) = 0.0036 / (0.0201 + 0.0036) = 0.152

Conclusion: Play = Yes

Example 2:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Outlook | Temp | Humidity | Windy | Play |
| Rainy | Cool | High | False | ? |

For Play = Yes:

P(Play=Yes | E)

= P(Play=Yes ∣ Outlook=Rainy,Temp=Cool,Humidity=High,Windy=False)

= P(Outlook=Rainy ∣ Play=Yes) \* P(Temp=Cool ∣ Play=Yes) \*  
P(Humidity=High ∣ Play=Yes) \* P(Windy=False ∣ Play=Yes) \* P(Play=Yes) / P(E)

= 3/9 \* 3/9 \* 3/9 \* 6/9 \* 9/14 / P(E) = 0.0159 / P(E)

For Play = No:

P(Play=No | E)

= P(Play=No ∣ Outlook=Rainy,Temp=Cool,Humidity=High,Windy=False)

= P(Outlook=Rainy ∣ Play=No) \* P(Temp=Cool ∣ Play=No) \*

P(Humidity=High ∣ Play=No) \* P(Windy=False ∣ Play=No) \* P(Play=No) / P(E)

= 2/5 \* 1/5 \* 4/5 \* 2/5 \* 5/14 / P(E) = 0.0091 / P(E)

Conversion into a probability by normalization:

* P(Play=Yes | E) = 0.0159 / (0.0159 + 0.0091) = 0.636
* P(Play=No | E) = 0.0091 / (0.0159 + 0.0091) = 0.364

Conclusion: Play = Yes

Example 3:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Outlook | Temp | Humidity | Windy | Play |
| Sunny | Hot | Normal | False | ? |

For Play = Yes:

P(Play=Yes | E)

= P(Play=Yes ∣ Outlook=Sunny,Temp=Hot,Humidity=Normal,Windy=False)

= P(Outlook=Sunny ∣ Play=Yes) \* P(Temp=Hot ∣ Play=Yes) \*  
P(Humidity=Normal ∣ Play=Yes) \* P(Windy=False ∣ Play=Yes) \* P(Play=Yes) / P(E)

= 2/9 \* 2/9 \* 3/9 \* 6/9 \* 9/14 / P(E) = 0.0071 / P(E)

For Play = No:

P(Play=No | E)

= P(Play=No ∣ Outlook=Sunny,Temp=Hot,Humidity=Normal,Windy=False)

= P(Outlook=Sunny ∣ Play=No) \* P(Temp=Hot ∣ Play=No) \*

P(Humidity=Normal ∣ Play=No) \* P(Windy=False ∣ Play=No) \* P(Play=No) / P(E)

= 3/5 \* 2/5 \* 4/5 \* 2/5 \* 5/14 / P(E) = 0.0274 / P(E)

Conversion into a probability by normalization:

* P(Play=Yes | E) = 0.0071 / (0.0071 + 0.0274) = 0.2058
* P(Play=No | E) = 0.0274 / (0.0071 + 0.0274) = 0.7942

Conclusion: Play = No

Example 4:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Outlook | Temp | Humidity | Windy | Play |
| ? | Hot | Normal | False | ? |

For Play = Yes:

P(Play=Yes | E)

= P(Temp=Hot,Humidity=Normal,Windy=False)

= P(Temp=Hot ∣ Play=Yes) \* P(Humidity=Normal ∣ Play=Yes) \* P(Windy=False ∣ Play=Yes) \* P(Play=Yes) / P(E)

= 2/9 \* 3/9 \* 6/9 \* 9/14 / P(E) = 0.0317 / P(E)

For Play = No:

P(Play=No | E)

= P(Temp=Hot,Humidity=Normal,Windy=False)

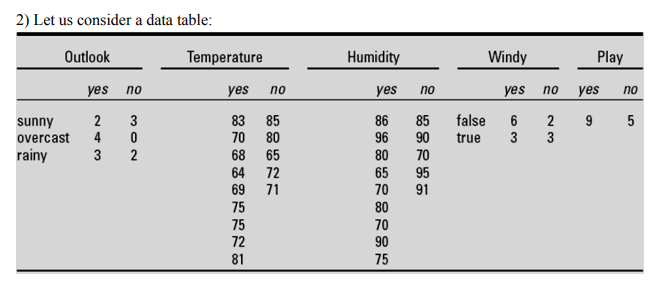
= P(Temp=Hot ∣ Play=No) \* P(Humidity=Normal ∣ Play=No) \* P(Windy=False ∣ Play=No) \* P(Play=No) / P(E)

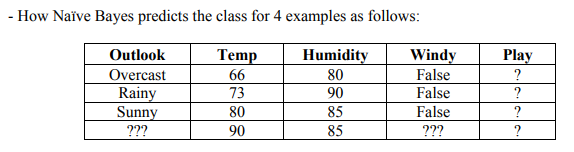
= 2/5 \* 4/5 \* 2/5 \* 5/14 / P(E) = 0.0457 / P(E)

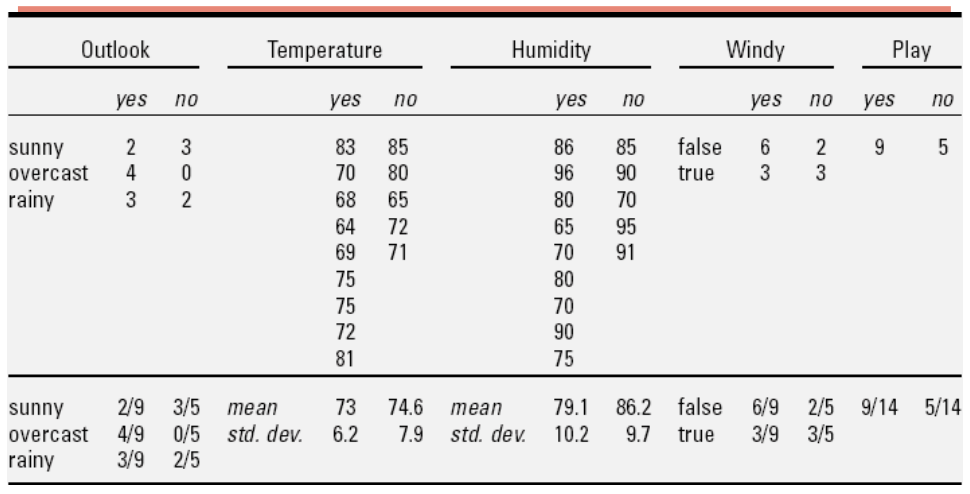
Conversion into a probability by normalization:

* P(Play=Yes | E) = 0.0317 / (0.0317 + 0.0457) = 0.4096
* P(Play=No | E) = 0.0457 / (0.0317 + 0.0457) = 0.5904

Conclusion: Play = Yes







Example 1:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Outlook | Temp | Humidity | Windy | Play |
| Overcast | 66 | 80 | False | ? |

In Example 1, we have to use Laplace Estimator to avoid zero probabilities.

For Play = Yes:

* P(Outlook=Overcast ∣ Play=Yes) = (4+1)/(9+3) = 5/12
* P(Windy=False ∣ Play=Yes) = (6+1)/(9+2) = 7/11
* P(Play=Yes) = (9+1)/(14+2) = 10/16 = 5/8

Numerical features:

* 0.0340
* 0.039

P(Play=Yes | E)

= P(Play=Yes ∣ Outlook=Overcast,Temp=Cool,Humidity=High,Windy=False)

= P(Outlook=Overcast ∣ Play=Yes) \* P(Temp=Cool ∣ Play=Yes) \*  
P(Humidity=High ∣ Play=Yes) \* P(Windy=False ∣ Play=Yes) \* P(Play=Yes) / P(E)

= 5/12 \* 0.0340 \* 0.0390 \* 7/11 \* 5/8 / P(E) = 0.00022 / P(E)

For Play = No:

* P(Outlook=Overcast ∣ Play=No) = (0+1)/(5+3) = 1/8
* P(Windy=False ∣ Play=No) = (2+1)/(5+2) = 3/7
* P(Play=No) = (5+1)/(14+2) = 6/16 = 3/8

Numerical features:

* 0.0279
* 0.0335

P(Play=No | E)

= P(Play=No ∣ Outlook=Overcast,Temp=Cool,Humidity=High,Windy=False)

= P(Outlook=Overcast ∣ Play=No) \* P(Temp=Cool ∣ Play=No) \*

P(Humidity=High ∣ Play=No) \* P(Windy=False ∣ Play=No) \* P(Play=No) / P(E)

= 1/8 \* 0.0279 \* 0.0335 \* 3/7 \* 3/8 / P(E) = 0.000019 / P(E)

Conversion into a probability by normalization:

* P(Play=Yes | E) = 0.00022 / (0.00022 + 0.000019) = 0.921
* P(Play=No | E) = 0.000019 / (0.00022 + 0.000019) = 0.179

Conclusion: Play = Yes

Example 2:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Outlook | Temp | Humidity | Windy | Play |
| Rainy | 73 | 90 | False | ? |

For Play = Yes:

Numerical features:

* 0.0643
* 0.0221

P(Play=Yes | E)

= P(Play=Yes ∣ Outlook=Rainy,Temp=Cool,Humidity=High,Windy=False)

= P(Outlook=Rainy ∣ Play=Yes) \* P(Temp=Cool ∣ Play=Yes) \*  
P(Humidity=High ∣ Play=Yes) \* P(Windy=False ∣ Play=Yes) \* P(Play=Yes) / P(E)

= 3/9 \* 0.0643 \* 0.0221 \* 6/9 \* 9/14 / P(E) = 0.000203 / P(E)

For Play = No:

Numerical features:

* 0.0495
* 0.0381

P(Play=No | E)

= P(Play=No ∣ Outlook=Rainy,Temp=Cool,Humidity=High,Windy=False)

= P(Outlook=Rainy ∣ Play=No) \* P(Temp=Cool ∣ Play=No) \*

P(Humidity=High ∣ Play=No) \* P(Windy=False ∣ Play=No) \* P(Play=No) / P(E)

= 2/5 \* 0.0495 \* 0.0381 \* 2/5 \* 5/14 / P(E) = 0.000108 / P(E)

Conversion into a probability by normalization:

* P(Play=Yes | E) = 0.000203 / (0.000203 + 0.000108) = 0.6527
* P(Play=No | E) = 0.000108 / (0.000203 + 0.000108) = 0.3473

Conclusion: Play = Yes

Example 3:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Outlook | Temp | Humidity | Windy | Play |
| Sunny | 80 | 85 | False | ? |

For Play = Yes:

Numerical features:

* 0.0340
* 0.0331

P(Play=Yes | E)

= P(Play=Yes ∣ Outlook=Sunny,Temp=Hot,Humidity=Normal,Windy=False)

= P(Outlook=Sunny ∣ Play=Yes) \* P(Temp=Hot ∣ Play=Yes) \*  
P(Humidity=Normal ∣ Play=Yes) \* P(Windy=False ∣ Play=Yes) \* P(Play=Yes) / P(E)

= 2/9 \* 0.0340 \* 0.0331 \* 6/9 \* 9/14 / P(E) = 0.000107 / P(E)

For Play = No:

Numerical features:

* 0.04
* 0.0408

P(Play=No | E)

= P(Play=No ∣ Outlook=Sunny,Temp=Hot,Humidity=Normal,Windy=False)

= P(Outlook=Sunny ∣ Play=No) \* P(Temp=Hot ∣ Play=No) \*

P(Humidity=Normal ∣ Play=No) \* P(Windy=False ∣ Play=No) \* P(Play=No) / P(E)

= 3/5 \* 0.04 \* 0.0408 \* 2/5 \* 5/14 / P(E) = 0.00014 / P(E)

Conversion into a probability by normalization:

* P(Play=Yes | E) = 0.000107 / (0.000107 + 0.00014) = 0.4332
* P(Play=No | E) = 0.00014 / (0.000107 + 0.00014) = 0.5668

Conclusion: Play = No

Example 4:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Outlook | Temp | Humidity | Windy | Play |
| ? | 90 | 85 | False | ? |

For Play = Yes:

Numerical features:

* 0.0076
* 0.0408

P(Play=Yes | E)

= P(Temp=Hot,Humidity=Normal,Windy=False)

= P(Temp=Hot ∣ Play=Yes) \* P(Humidity=Normal ∣ Play=Yes) \* P(Windy=False ∣ Play=Yes) \* P(Play=Yes) / P(E)

= 0.0076 \* 0.0408 \* 6/9 \* 9/14 / P(E) = 0.000133 / P(E)

For Play = No:

Numerical features:

* 0.0076
* 0.0408

P(Play=No | E)

= P(Temp=Hot,Humidity=Normal,Windy=False)

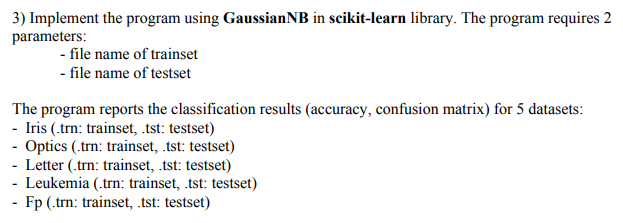
= P(Temp=Hot ∣ Play=No) \* P(Humidity=Normal ∣ Play=No) \* P(Windy=False ∣ Play=No) \* P(Play=No) / P(E)

= 0.0076 \* 0.0408 \* 2/5 \* 5/14 / P(E) = 0.000044 / P(E)

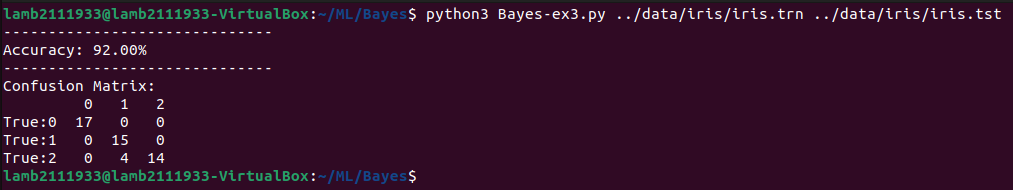
Conversion into a probability by normalization:

* P(Play=Yes|E) = 0.000133 / (0.000133 + 0.000044) = 0.7514
* P(Play=No|E) = 0.000044 / (0.000133 + 0.000044) = 0.2486

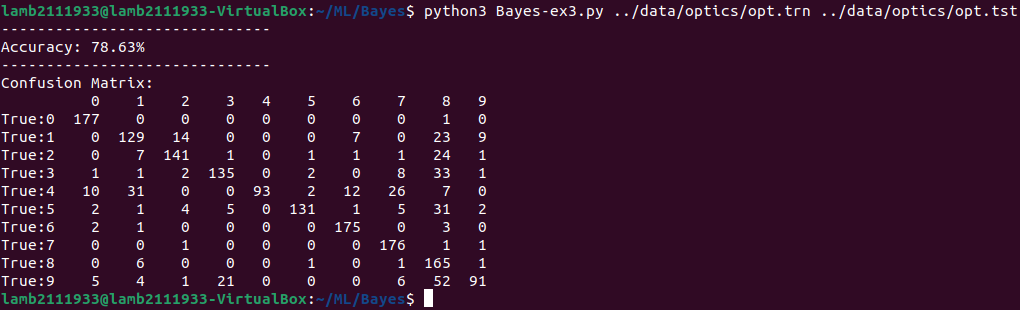
Conclusion: Play = Yes



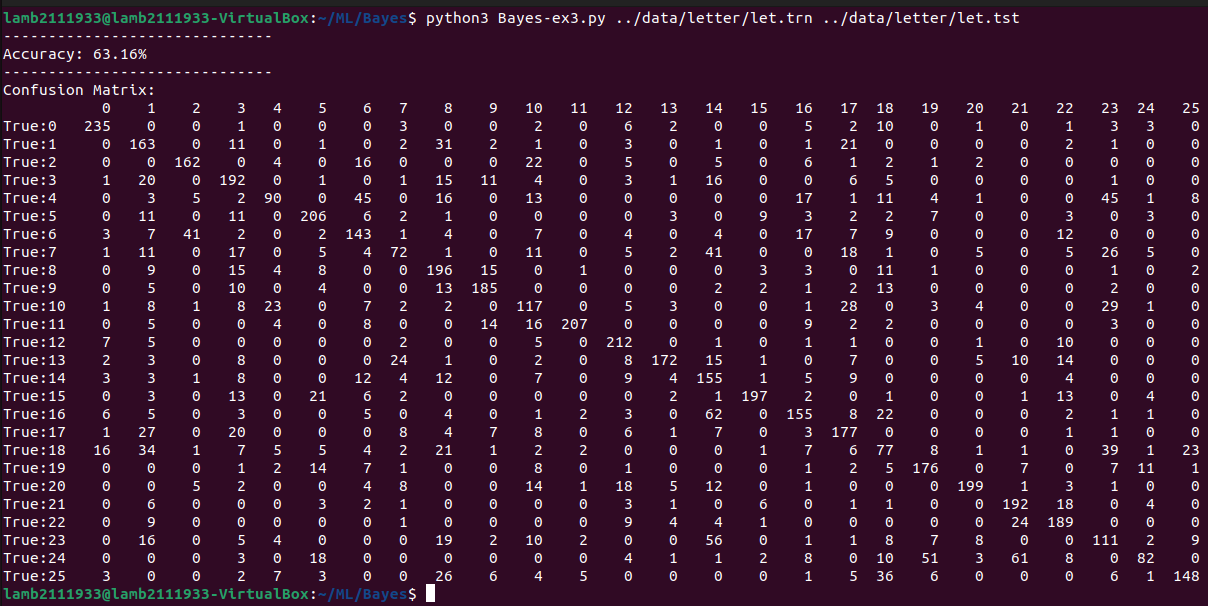
Iris dataset:



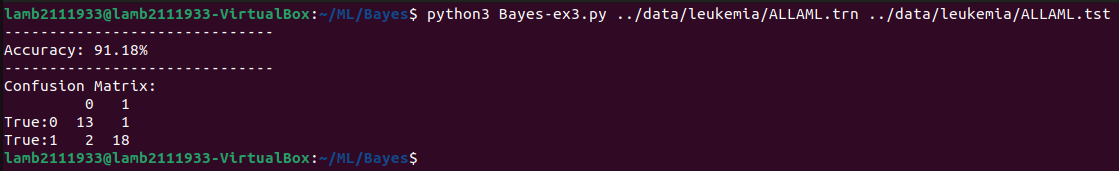
Optics dataset:



Letter dataset:



Leukemia dataset:



Fp dataset:

