# Bayes Theorem

In probability theory and statistics, Bayes' theorem (alternatively Bayes' law or Bayes' rule; recently Bayes) named after Thomas Bayes, describes the probability of an event, based on prior knowledge of conditions that might be related to the event

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eq $$P(A \mid B) = \frac{P(B \mid A)P(A)}{P(B)}$$

A & B: events

P( A | B ) : the probability of event A occurring given thatB is true. It is also called the posterior probability of A given B

P( B | A) : the probability of event B occurring given that A is true. It can also be interpreted as the likelihood of A given a fixed B

P(A) and P(B) are the probabilities of observing A and B respectively without any given conditions; they are known as the marginal probability or prior probability.

exemple:

below is a statistic table of clothing shop,the owner get cloths from 2 factory fact A & Fact B

| | FACT A | FACT B | total |
|---|---|---|---|
| Shirt | 65 | 55 | 120 |
| trousers | 72 | 25 | 97 |
| jacket | 44 | 52 | 96 |
| chapeau | 21 | 23 | 44 |
| | | | 357 |

P(SHIRT) All shirt / ALL cloth
P(A | SHIRT) = Shirt Fact A / ALL Shirt
P(B | SHIRT) = Shirt Fact B / ALL Shirt
same way with trousers jacket chapeau..........

P(A) = P(A | SHIRT) * P(SHIRT) + P(A | trousers) * P(trousers) +........
P(B) = P(B | SHIRT) * P(SHIRT) + P(B | trousers) * P(trousers) +. .......

computing.....
FACT A:
P(SHIRT) = 120/357=0.336 P(trousers) = 97/357= 0.271 P(jacket) = 96/357=0.268
P(chapeau) = 44/357 =0.123

P(A | SHIRT) = 65/120 =0.541 P(A | trousers) = 72/96 =0.75 P(A | jacket) = 44/96 =0.485
P(A | chapeau) = 21/44=0.477

P(A) = (0.547*0.336) + (0.75*0.271) + (0.485*0.268) + (0.477*0.123)

P(A) = 0,1837+0,2032+0,1299+0,0586 = $\boxed{0,5754}$

FACT B:
P(SHIRT) = 120/357=0.336 P(trousers) = 97/357= 0.271 P(jacket) = 96/357=0.268
P(chapeau) = 44/357 =0.123
P(B | SHIRT) =0.458 P(B | trousers) =0.257 P(B | jacket) =0.541
P(B | chapeau) =0.522
P(B) = (0.336*0.458) + (0.257*0.271) + (0.541*0.268) + (0.123*0.522)

P(B) = 0,1538 +0,0696+0,1449+0,0642 = $\boxed{0,4325}$

P(A) > P(B) ... that means .. cloth from factory A is most wanted that factory B

another exemple
index A in stock market

| Price | Buyers | Sellers | |
|---|---|---|---|
| 50 | 70% | 30% | 100 |
| 60 | 68 % | 32% | 100 |
| 80 | 38% | 62% | 100 |
| 90 | 55% | 45% | 100 |
| | | | 400 |

$P(P50) = 100 / 400 = 0.25$
$P( B \mid P50) = 70 / 100=0.7$ $\quad$ $P( S \mid P50) = 30 / 100=0.3$

$P(P60) = 100 / 400 = 0.25$
$P( B \mid P60) = 68 / 100=0.68$ $\quad$ $P( S \mid P60) = 32 / 100=0.32$

$P(P80) = 100 / 400 = 0.25$
$P( B \mid P80) = 38 / 100=0.38$ $\quad$ $P( S \mid P80) = 62 / 100=0.62$

$P(P90) = 100 / 400 = 0.25$
$P( B \mid P90) = 55 / 100=0.55$ $\quad$ $P( S \mid P90) = 45 / 100=0.45$

$P(B) = (0.7 * 0.25) + (0.68 * 0.7) + (0.7 * 0.38) + (0.7 * 0.55)$
$P(B) = 0{,}175 + 0.476 + 0.266+0.385 = 1{,}302$

$P(S) = (0.7 * 0.3) + (0.7 * 0.32) + (0.7 * 0.62) + (0.7 * 0.45)$
$P(S) = 0{,}21+ 0{,}224+ 0{,}434+0{,}315 = 1{,}183$

$P(B) > P(S)$ ....... thats means Buyers dominate the market eggs incubator

| | Temperature | $O_2$ | $CO_2$ | rate | |
|---|---|---|---|---|---|
| Test 1 | 20 | 20 | 2 | bad res | |
| Test2 | 30 | 21 | 11 | good res | |
| Test3 | 35 | 22 | 10 | very gd res | |
| Test4 | 40 | 18 | 14 | good res | |
| Test5 | 45 | 11 | 21 | bad res | |
| Test6 | 50 | 30 | 4 | very bad res | |
| Test7 | 60 | 22 | 14 | very bad res | |
| | 280 | 144 | 76 | | 500 |

**Predict The rate of the following parameter:**

**parameter 01:**
**temp = 38**
**O2 = 4**
**Co2 = 5**

**to define the rate ..we have to Calcul the Propability density Function of every parametre , we have 4 class**
***bad , good , very good , very bad***

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

**lets start with first class: ( BAD )**

**----------------------f(x) for P(temp | BAD) ----------------------------**
**1-calc Mean for bad**
**u = Sum(temp (bad)) / N**
**u = 20+45 / 2= 32.5**

| Temperature | O2 | CO2 | rate |
|---|---|---|---|
| 20 | 20 | 2 | bad res |
| 30 | 21 | 11 | good res |
| 35 | 22 | 10 | very gd res |
| 40 | 18 | 14 | good res |
| 45 | 11 | 21 | bad res |

**calc Variance:**
**V = sum( temp i(bad) - mean)² / N-1**
**V = 312.5**
**Sigma = squart root(V) = 17.67767**

**f(x) = 1 / Sigma*(sqrt 2PI) . exp ( - ( temp_param1 - u )² / 2* sigma²)**
**f(x) = 1 / 17.67767*(sqrt 2PI) . exp ( - ( 38 - 32.5 )² / 2* 17.67767²)**

**f (temp | BAD) = 0.02150**

**----------------------f(x) for P(o2 | BAD) ----------------------------**
**1-calc Mean for bad**
**u = 20+11/ 2= 15.5**
**calc Variance:**
**V = 40.5**
**Sigma = squart root(V) = 6.363961**

| Temperature | O2 | CO2 | rate |
|---|---|---|---|
| 20 | 20 | 2 | bad res |
| 30 | 21 | 11 | good res |
| 35 | 22 | 10 | very gd res |
| 40 | 18 | 14 | good res |
| 45 | 11 | 21 | bad res |

**f(x) = 1 / 6.363961*(sqrt 2PI) . exp ( - ( 19 - 15.5 )² / 2* 6.363961²)**

**f (o2 | BAD) = 0.05389**

**----------------------f(x) for P(co2 | BAD) ----------------------------**
**u = 21+2/ 2= 11.5**
**V = 180.5**
**Sigma = 13.435029**
**f (co2 | BAD) = 0.02641**

---------calc Propability of BAD:

P(BAD) = BAD count / All rate

P(bad) = 2 / 7 = 0.28

P(bad | param1) = P(temp | BAD) *P(bad) + P(o2 | BAD) *P(bad)+P(co2 | BAD) *P(bad)

P(bad | param1) =0.02150 * 0.28 + 0.05389 * 0.28 + 0.02641 * 0.28

P(bad | param1) = 0,00602 +0,015064+0,073948 = 0,095028

## second class: ( GOOD )

----------------------f(x) for P(temp | good) ----------------------------

u = Sum(temp (good)) / N

u = 30+40/ 2= 35

calc Variance:

V = sum( temp i(good) - mean)² / N-1 V = 50

Sigma = squart root(V) = 7.0710678

f (temp | good) = 0.05156

----------------------f(x) for P(o2 | good) ----------------------------

u = 21+18/ 2= 19.5

calc Variance:

V = 4.5

Sigma = squart root(V) = 2.1213203

f (o2 | good) = 0.18291

----------------------f(x) for P(co2 | good) ----------------------------

u = 11+14/ 2= 12.5

V = 4.5

Sigma = 2.1213203

f (co2 | good) = 0.00036

---------calc Propability of good:

P(good) = good count / All rate

P(bad) = 2 / 7 = 0.28

P(good | param1) = P(temp | good) *P(good) + P(o2 | BAD) *P(good)+P(co2 | good)*P(good)

P(good | param1) =0.05156 * 0.28 + 0.18291 * 0.28 + 0.00036 * 0.28

P(good | param1) =0,144368 + 0,0512148 + 0,0001008 =0,1956836

# third class: ( very good )

**u = Sum(temp (very good)) / N**

**u = 35/1 = 35**
**calc Variance:**
**V = 0**
**Sigma = squart root(V) = 0**
**f (temp | very good) = 0**

**Correction**

$\mu$ Paramètre de position (réel)
$b > 0$ Paramètre d'échelle (réel)

$x \in (-\infty; +\infty)$

$$\frac{1}{2\,b} \exp\left(-\frac{|x-\mu|}{b}\right)$$

**x= (38)**

**f (temp | very good) = 1/2 exp(- 3)**

**f (temp | very good) = 0.02489**

**----------------------f(x) for P(o2 | very good) -----------------------------**
**u = 22/1= 22**
**calc Variance:**
**V = 0**
**Sigma = squart root(V) = 0**
**f (o2 | very good) = 0**
**x= (19)**
**f (o2 | very good) = 1/2 exp(- 3)**
**f (o2 | very good) = 0.02489**

**----------------------f(x) for P(co2 | very good) -----------------------------**
**u = 10/ 1= 10**
**V = 0**
**Sigma = 0**
**f (co2 | very good) = 0.00036**

**x= (19)**
**f (co2 | very good) = 1/2 exp(- 9)**
**f (co2 | very good) = 0.0001234098**

**---------calc Propability of good:**
**P(very good) = very good count / All rate**
**P(bad) = 1 / 7 = 0.1428**
**P(v good | param1) = P(co2 | vgood) *P(vgood) + P(co2 | vgood) *P(vgood)+P(co2 | vgood)*P(vgood)**
**P(very good | param1) = 0.02489 * 0.1428 + 0.02489 * 0.1428 + 0.0001234098* 0.1428**

**P(very good | param1) = 0,003554292 + 0,003554292 +0,00001762291944 =0,0071262**

## fourth class: (  very bad  )

**u = Sum(temp (very bad)) / N**

**u = 50/60 = 55**
**calc Variance:**
**V = 50**
**Sigma = squart root(V) =7.0710678**

**f (temp | very bad) = 0.00314**

**----------------------f(x) for P(o2 | very bad) ----------------------------**
**u =  30/22= 26**
**calc Variance:**
**V = 32**
**Sigma = squart root(V) = 5.6568542**

**f (o2 | very bad) = 0.03280**

**----------------------f(x) for P(co2 | very bad) ----------------------------**
**u =  4/ 14= 9**
**V = 50**
**Sigma = 7.0710678**
**f (co2 | very bad) = 0.04808**

**---------calc Propability of good:**
**P(very bad) = very bad count / All rate**
**P(very bad) = 2 / 7   =0.28**
**P(v bad | param1) = P(co2 | vbad) *P(vbad) + P(co2 | vbad) *P(vbad)+P(co2 | vbad)*P(vbad)**

**P(very bad | param1) = 0.00314*  0.28    +        0.03280   *  0.28  +    0.04808* 0.28**

**P(very good | param1) = 0,0008792 + 0,009184 +0,0134624=0,0071262  = 0,0235256**

**P(bad | param1) = 0,095028**
**P(good | param1) = 0,1956836**
**P(very good | param1) = 0,0071262**
**P(very good | param1) = 0,0235256**

**Param 01 : temp= 38 O2=19 CO2=5**
**classified in (Good )**