Lecture-1 26/9/19

Introduction to probability

<u>Philosophy:-</u>

Make "reasonable" assumptions ($\equiv$ mathematical axioms) to build a framework

Reason about real-world examples using the model built upon axioms.

<u>Statements:</u> "The probability of an event A is p".

A = Class is interactive today & weather is not so-hot in Chennai

$p = \frac{1}{2}, \frac{1}{4}, - \dots$ or "low", "high"

Experiment $\rightarrow$ outcome

Sample space Ω = set of all possible outcomes

Example 1)

A coin is tossed

$$\Omega = \{H, T\}$$

Some events:

1. Outcome is a head $\{H\}$
2. —— " —— not a head $\{H\}^c$
3. —— " —— a head or a tail $\{H\} \cup \{T\}$
4. —— " —— neither a head nor a tail $\{H\}^c \cap \{T\}^c$

Example 2)

Throw a die

$$\Omega = \{1, 2, --- 6\}$$

Some events:

1. Outcome is 1 $\qquad \{1\}$
2. — " — even $\qquad \{2,4,6\}$
3. — " — ≤ 3 & even $\qquad \{1,2,3\} \cap \{2,4,6\}$
4. — " — is not odd $\qquad \{2,4,6\}$

Event is a subset of Ω

A, B are events, then it is "reasonable" to be concerned about

$$A \cup B, \quad A \cap B, \quad A^c$$

If $A \cap B = \emptyset$, then A & B are disjoint

Let $\mathcal{F}$ be a collection of events.

(a) If $A, B \in \mathcal{F}$, then $A \cup B, A \cap B \in \mathcal{F}$

(b) If $A \in \mathcal{F}$, then $A^c \in \mathcal{F}$

(c) $\phi \in \mathcal{F}$.

Such an $\mathcal{F}$ is called a "Field".

Note: ① $\Omega \in \mathcal{F}$.

② If $A_1, \ldots, A_n \in \mathcal{F}$, then

$\bigcup_{i=1}^{n} A_i$ and $\bigcap_{i=1}^{n} A_i$ are in $\mathcal{F}$.

Is a field adequate for understanding probability of an event?

Yes, if Ω is finite.

No if Ω is infinite

Example 3) A coin is tossed repeatedly until a head appears

$\Omega = \{\omega_1, \omega_2, \text{-----}\}$

$\omega_i =$ $(i-1)$ tails & ith toss is a head

$A =$ first head appears after a even # of tosses

$= \{\omega_2, \omega_4, \omega_6 \text{---}\}$

$=$ infinite countable union of elements of Ω

We want $A \in \mathcal{F}$

So,

<u>Def</u>: A collection $\mathcal{F}$ of subsets of Ω is a σ-field if

(a) $\phi \in \mathcal{F}$ (b) $A_1, A_2, \text{----} \in \mathcal{F} \Rightarrow \bigcup_{i=1}^{\infty} A_i \in \mathcal{F}$

(c) $A \in \mathcal{F} \Rightarrow A^c \in \mathcal{F}$

Note: $\bigcap_{i=1}^{\infty} A_i \in \mathcal{F}$

Examples:

① $\mathcal{F} = \{\phi, \Omega\}$ smallest σ-field

② For any event A, define

$$\mathcal{F} = \{\phi, \Omega, A, A^c\}$$

$\mathcal{F}$ is a σ-field.

③ If Ω is finite, then the power set $\{0,1\}^{\Omega}$ is a σ-field.

If Ω is infinite, power set is too large to assign probability to all its members. (beyond scope of this course).

Bottom line:- $(\Omega, \mathcal{F})$ for any experiment.

Def: A probability measure P on $(\Omega, \mathcal{F})$ is a function $P: \mathcal{F} \to [0,1]$ satisfying

(a) $P(\Omega) = 1$

(b) $A_1, A_2, \ldots$ disjoint, i.e., $A_i \cap A_j = \phi$, $i \neq j$

then, $P\left(\bigcup_{i=1}^{\infty} A_i\right) = \sum_{i=1}^{\infty} P(A_i)$

Lecture-2 1/10/19

"Cardinality & Countability"

Recall: $f : A \to B$

f is <u>injective</u> if $x \neq y \Rightarrow f(x) \neq f(y)$

<u>surjective</u> if $\forall y \in B \ \exists x$ s.t. $f(x) = y$

bijective if it is injective & surjective

$|B| \geq |A|$ if $\exists$ injective f from A to B.

$|A| = |B|$ if $\exists$ bijective f from A to B.
"equi-cardinal"

Set Ω is finite if $\exists n$ s.t.
$([n] = \{1, \ldots n\})$ Ω and $[n]$ are equi-cardinal.

Ω is countable if Ω and

$\mathbb{N} = \{1, 2, 3, \ldots\}$ are equi-cardinal

Facts:

① Set of integers $\mathbb{Z}$ is countable

$$f(n) = \begin{cases} n/2 & \text{if } n \text{ is even} \\ -\left(\frac{n-1}{2}\right) & \text{if } n \text{ is odd} \end{cases}$$

② $\mathbb{N} \times \mathbb{N}$ is countable

$(1,1), (1,2), (2,1), (1,3), (2,2), (3,1) \ldots$

③ $\mathbb{Z} \times \mathbb{Z}$ is countable

④ Set of rational numbers $\mathbb{Q}$ is countable

⑤ Set of real numbers $\mathbb{R}$ is "not" countable

$x \in [0,1]$ $\qquad 0.x_1 x_2 x_3 ----$

Suppose $\exists f : \mathbb{N} \to [0,1]$ which is a bijection

$f(1), f(2), ----$

$$\left.\begin{array}{l} f(1) = \quad 0.X_{11}\ X_{12} ---- \\ f(2) = \quad 0.X_{21}\ X_{22} --- \\ \vdots \end{array}\right\} \text{list}$$

Let $y = 0.Y_1 Y_2 Y_3 ----$

Y_i = any number s.t. $Y_i \neq X_{ii}$

$y \notin$ list above

$\Rightarrow \nexists f$ from $\mathbb{N}$ to $[0,1]$ that is onto

$\Rightarrow \mathbb{R}$ is not countably infinite

6) $A_1, A_2, \ldots$ subsets of Ω

If each A_i is countable, then

$$\bigcup_{i \in \mathbb{N}} A_i \text{ is countable.}$$

Infinite Sums

$\Omega = \{\omega_1, \omega_2, \ldots\}$

In probability, we make statements like

$$\sum_{\omega \in \Omega} p(\omega) = 1$$ with a countable Ω.

Ω is countable

$\exists$ bijective $\phi : \mathbb{N} \to \Omega$

$\omega_1 = \phi(1)$, $\omega_2 = \phi(2)$, $\ldots$

Partial sums $x_n = p(\omega_1) + \cdots + p(\omega_n)$

$p \geq 0 \Rightarrow x_1 \leq x_2 \leq x_3 \cdots$

$$x_n \xrightarrow[n\to\infty]{} \begin{cases} \text{finite number} \\ +\infty \end{cases}$$

$$\sum_{\omega} p(\omega) = \left\{ L := \lim_{n\to\infty} x_n \right\}$$

Question: If $\exists$ a different bijection φ

$\omega_1' = \varphi(1), \cdots$

$y_n = p(\omega_1') + \cdots + p(\omega_n')$

$$L' = \lim_{n\to\infty} y_n$$

Is it true that $L = L'$?

Yes. Proof for $p \geq 0$

Fix n. $x_n = p(\omega_1) + \cdots + p(\omega_n)$

ψ surjective $\Rightarrow$ $\{\omega_1, \ldots \omega_n\} \subseteq \{\omega'_1, \ldots \omega'_m\}$
for some m

$$p(\omega_1) + \cdots + p(\omega_n) \leq p(\omega'_1) + \cdots + p(\omega'_m)$$

$$x_n \leq y_m$$

y_m increasing $\Rightarrow$

$$x_n \leq y_m \leq y_{m+1} \leq \cdots$$

$$\Rightarrow x_n \leq L'$$

$$\Rightarrow \lim_{n\to\infty} x_n \leq L'$$

$$\Rightarrow L \leq L'$$

Exchanging ϕ & φ, we obtain $L' \leq L$
& hence $L = L'$

General Case :- A similar conclusion holds when P is not necessarily non-negative.

So, If

$f : \Omega \to \mathbb{R}$ $\quad \sum_{\omega \in \Omega} f(\omega)$ summable

and the sum is S, then

for any bijection $\phi : \mathbb{N} \to \Omega$,

$$\lim_{n \to \infty} f(\phi(1)) + \cdots + f(\phi(n)) = S$$

Lecture - 3 Probability 9/10/10

Suppose we repeat an experiment a large # of times

$N(A)$ = # of occurences of event A in N trials

As N increases, $\frac{N(A)}{N}$ stabilizes

$\downarrow$

probability of event A

$A = \phi$, $N(\phi) = 0$, $A = \Omega$, $N(\Omega) = N$

A, B disjoint

$$N(A \cup B) = N(A) + N(B)$$
$$P(A \cup B) = P(A) + P(B)$$

$A_1 \dots A_n$ disjoint

Want $P\left(\bigcup_{i=1}^{n} A_i\right) = \sum_{i=1}^{n} P(A_i)$

From an earlier example, we can argue for "countable" additivity.

Def: A probability measure P on $(\Omega, \mathcal{F})$ is a function

$P : \mathcal{F} \to [0,1]$ satisfying

(i) $P(\Omega) = 1$

(ii) if $A_1, A_2, \dots$ disjoint & in $\mathcal{F}$,

i.e., $A_i \in \mathcal{F}\ \forall i$, $A_i \cap A_j = \phi$ $\forall i \neq j$

then $$P\left(\bigcup_{i=1}^{\infty} A_i\right) = \sum_{i=1}^{\infty} P(A_i)$$

PROPERTIES :

① $P(A^c) = 1 - P(A)$ since

$A \cup A^c = \Omega$ & $P(\Omega) = 1$

② $A \subset B \Rightarrow P(A) \leq P(B)$

$B = A \cup (A^c \cap B)$

$P(A) \leq P(A) + P(A^c \cap B) = P(B)$

$\because P(A^c \cap B) \geq 0$

③ $P(A \cup B) = P(A) + P(B) - P(A \cap B)$

$A \cup B = (A \cap B^c) \cup (A^c \cap B) \cup (A \cap B)$

$$P(A\cup B) = P(A\cap B^c) + P(A^c\cap B) + P(A\cap B)$$

$$= \left(P(A\cap B^c) + P(A\cap B)\right)$$

$$+ \left(P(A^c\cap B) + P(A\cap B)\right)$$

$$- P(A\cap B)$$

$$= P(A) + P(B) - P(A\cap B)$$

④ H.W.

$$P(A\cup B\cup C) = P(A) + P(B) + P(C)$$

$$- P(A\cap B) - P(A\cap C) - P(B\cap C)$$

$$+ P(A\cap B\cap C)$$

& more generally,

$A_1 \ldots A_n$ events

$$P\left(\bigcup_{i=1}^{n} A_i\right) = \sum_i P(A_i) - \sum_{i<j} P(A_i \cap A_j)$$

$$+ \sum_{i<j<k} P(A_i \cap A_j \cap A_k) + \cdots$$

$$\cdots + (-1)^{n+1} P(A_1 \cap \cdots \cap A_n)$$

Hint: Use induction.

(5) Two examples

Die is thrown once

$\Omega = \{1 \ldots 6\}$ $\quad \mathcal{F} = \{0,1\}^{\Omega}$

$$P(A) = \sum_{i \in A} p_i \quad \text{for any } A \subseteq \Omega$$

$P_1 \ldots P_6 \in [0,1]$ & $\sum_{i=1}^{6} p_i = 1$

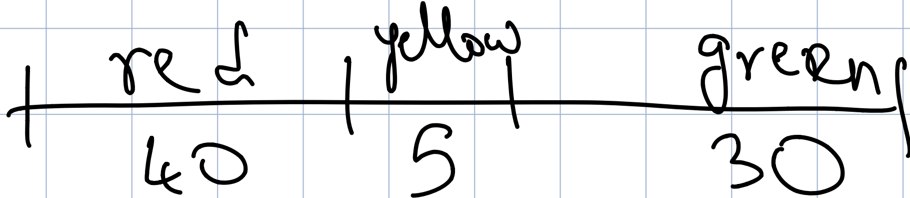
Another example:

Traffic light

$\Omega = \{\text{green}, \text{yellow}, \text{red}\}$

$P(\{\text{green}\}) = P(\{\text{yellow}\}) = P(\{\text{red}\}) = \frac{1}{3}$

Looking closer! cycle of length 75



$P(\{\text{green}\}) = \frac{30}{75} = \frac{2}{5}$

$P(\{\text{red}\}) = \frac{8}{15}$, $P(\{\text{yellow}\}) = \frac{1}{15}$

(6) $A_1, A_2, \ldots$ increasing sequence of events

$$A_1 \subseteq A_2 \subseteq A_3 \subseteq \cdots$$

Let $A = \bigcup_{i=1}^{\infty} A_i = \lim_{i \to \infty} A_i$

Then, $\boxed{P(A) = \lim_{i \to \infty} P(A_i)}$

<u>Proof</u> :-

$$A = A_1 \cup (A_2 \setminus A_1) \cup (A_3 \setminus A_2) \cdots$$

disjoint union

$$P(A) = P(A_1) + \sum_{i=1}^{\infty} P(A_{i+1} \setminus A_i)$$

$$= P(A_1) + \lim_{n\to\infty} \sum_{i=1}^{n-1} \left(P(A_{i+1}) - P(A_i)\right)$$

$$= \lim_{n\to\infty} P(A_n)$$

$\blacksquare$

H.W. If $B_1, B_2, \ldots$ decreasing sequence of events, i.e.,

$$B_1 \supseteq B_2 \supseteq B_3 \supseteq \cdots$$

and $B = \bigcap_{i=1}^{\infty} B_i = \lim_{i\to\infty} B_i$

Then, $P(B) = \lim_{i\to\infty} P(B_i)$

Hint: Take complements & use the claim above for unions.

Lecture - 4

10/10/19

⑦ $A_1, A_2, \ldots \in \mathcal{F}$ $(\Omega, \mathcal{F}, P)$

Then, $P\left(\bigcup_{i=1}^{\infty} A_i\right) = \lim_{n\to\infty} P\left(\bigcup_{i=1}^{n} A_i\right)$

"Continuity of probability measure".

<u>Proof:</u> Let $B_1 = A_1$, $B_2 = A_2 \setminus A_1, \ldots$

$$B_n = A_n \setminus (A_1 \cup \ldots A_{n-1})$$

$$B_i \cap B_j = \phi \quad i \neq j$$

$$P\left(\bigcup_{i=1}^{\infty} A_i\right) = P\left(\bigcup_{i=1}^{\infty} B_i\right)$$

$$= \sum_{i=1}^{\infty} P(B_i)$$

$$= \lim_{n \to \infty} \sum_{i=1}^{n} P(B_i)$$

$$= \lim_{n \to \infty} P\left(\bigcup_{i=1}^{n} B_i \right)$$

$$= \lim_{n \to \infty} P\left(\bigcup_{i=1}^{n} A_i \right)$$

$\blacksquare$

(8) $A_1, A_2, \ldots$ events

$$P\left(\bigcup_{i=1}^{\infty} A_i \right) \leq \sum_{i=1}^{\infty} P(A_i)$$

"Union bound"

<u>Proof:</u> B_i as before (see (7))

$$P\left(\bigcup_{i=1}^{\infty} A_i \right) = P\left(\bigcup_{i=1}^{\infty} B_i \right)$$

$$= \sum_{i=1}^{\infty} P(B_i)$$

$$B_i \subseteq A_i \Rightarrow P(B_i) \leq P(A_i)$$

$$\lim_{n\to\infty} \sum_{i=1}^{n} P(B_i) \leq \lim_{n\to\infty} \sum_{i=1}^{n} P(A_i)$$

So, $$P\left(\bigcup_{i=1}^{\infty} A_i\right) \leq \sum_{i=1}^{\infty} P(A_i)$$

$\blacksquare$

The case of an uncountably infinite Ω

$$\Omega = \{\omega \mid 0 \leq \omega \leq 1\}$$

Outcome ω is drawn from Ω, with no preference for one interval over another.

So, intervals in $\mathcal{F}$,

$$P(\omega \in [a,b]) = b-a, \quad 0 \leq a \leq b \leq 1$$

$$P(\{a\}) = 0$$

$$P((a,b)) = b-a$$

$$[0,1] = \bigcup_{x \in [0,1]} \{x\}$$

$$\sum_{x \in \Omega} P(x) \neq 0$$

since LHS has an uncountable union

Conditional probability

Frequency argument:

Census: Village with families of 2 children

Q1) What is the probability that $\underbrace{\text{both kids are boys}}_{\text{event } A}$?

Q2) Probability of A given that at least one kid is a boy?

Poll N families & observe # occurences of $A = N(A)$

$$P(A) = \frac{N(A)}{N}$$

For Q2) Consider only outcomes for which B holds.

In this subset, proportion of A is $\dfrac{N(A\cap B)}{N(B)}$

$$\frac{N(A\cap B)}{N(B)} = \frac{P(A\cap B)}{P(B)} =: P(A|B)$$

Alternately, given B occurs, A occurs only if $A\cap B$ occurs

$$P(A|B) = c\,P(A\cap B)$$

$$P(\Omega \mid B) = 1$$

$$\Rightarrow \quad c\,P(B) = 1 \quad \Rightarrow \quad c = \frac{1}{P(B)}$$

<u>Def</u>: If $P(B) > 0$, then the conditional probability that A occurs given that B occurs is

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

<u>Example</u>: Throw 2 dice

B = first dice shows 3

A = sum > 6

$$\Omega = \{1, 2, \ldots 6\}^2$$

$\mathcal{F} =$ all subsets of Ω

$$P(A) = |A|/36$$

$$B = \{(3, b) \mid 1 \leq b \leq 6\}$$

$$A = \{(a, b) \mid a + b > 6\}$$

$$A \cap B = \{(3,4), (3,5), (3,6)\}$$

$$P(A \mid B) = \frac{P(A \cap B)}{P(B)} = \frac{3}{6} = \frac{1}{2}$$

<u>Example</u> Family problem

Two children → Prob. of both being boys

→ Prob. of both boys given firstone is

$$\Omega = \{GG, GB, BG, BB\}$$

$$P(GG) = \;---\; = P(BB) = \frac{1}{4}$$

$$P(BB \mid \text{one boy at least})$$

$$= P(BB \mid \underbrace{GB \cup BG \cup BB}_{(*)})$$

$$= \frac{P(BB)}{P(*)} = \frac{1}{3}$$

$P(BB \mid \text{younger one is a boy})$

$= \frac{1}{2}$

Lectures 5 & 6 12/10/19

Total probability rule

A family $B_1, \dots, B_n$ of events is a partition for the set Ω if

$$B_i \cap B_j = \phi, \; i \neq j \;\; \& \;\; \bigcup_{i=1}^{n} B_i = \Omega$$

For any event A, & partition $\{B_1, \dots, B_n\}$ with $P(B_i) > 0 \; \forall i$,

$$P(A) = \sum_{i=1}^{n} P(A \mid B_i) P(B_i)$$

Pf:- $A = (A \cap B) \cup (A \cap B^c)$

$$P(A) = P(A \cap B) + P(A \cap B^c)$$

$$= P(A/B)\,P(B) + P(A/B^c)\,P(B^c)$$

H.W. Generalize.

Example:

Urn 1	Urn 2
2W, 3B	3W, 4B

Pick a ball from urn 1 & put it into urn 2.

Draw a ball from urn 2

A = final ball is blue

B = first — " —

$$P(A) = P(A/B)\,P(B) + P(A/B^c)\,P(B^c)$$

$$= \frac{5}{8} \times \frac{3}{5} + \frac{4}{8} \times \frac{2}{5} = \frac{23}{40}$$

Example : Monty hall problem

3 doors → Car behind one & goats behind other two

You choose 1. Presenter opens door 2 & reveals a goat

Prob. of winning a car by switching to 3 is

$$P(\text{Car behind } 3 \mid \text{Presenter opened } 2, \text{You chose } 1)$$

$= \frac{2}{3}$. H.W.

Independence & conditional independence

Occurence of B changes prob. of A $P(A/B)$

If B has no impact, i.e., $P(A/B) = P(A)$, then A & B are independent

Def: Events A & B are independent if

$$P(A \cap B) = P(A)\, P(B)$$

In general, $\{A_i, i \in I\}$ independent if

$$P\left(\bigcap_{i \in J} A_i\right) = \prod_{i \in J} P(A_i),$$

for any finite a subset J of I.

Note:- If $\{A_i, i \in I\}$ satisfies

$$P(A_i \cap A_j) = P(A_i)\, P(A_j), \quad i \neq j,$$

then $\{A_i, i \in I\}$ is pair-wise independent.

Example:-

$$\Omega = \{abc, acb, cab, cba, bca, bac, aaa, bbb, ccc\}$$

$$P(\{\omega\}) = \frac{1}{9} \quad \forall\, \omega \in \Omega$$

$A_k =$ kth letter is a.

$$P(A_1 \cap A_2 \cap A_3) = 1/9$$

$$P(A_1) = \frac{3}{9} = P(A_2) = P(A_3)$$

So, $\{A_1, \ldots A_3\}$ is <u>not</u> independent.

$$P(A_1 \cap A_2) = \frac{1}{9} = P(A_1) \cdot P(A_2)$$

Conditional independence

Let C be an event with $P(C) > 0$

A & B conditionally independent given C, if

$$P(A \cap B \mid C) = P(A \mid C)\, P(B \mid C)$$

<u>Note:</u>

Independence $\not\Leftrightarrow$ Conditional independence

GAMBLER'S RUIN

Audi → costs N units

You have "k" units

Game with a bank manager is

1) Toss a fair coin

2) if heads, manager gives you one unit
else, you lose one unit

Game goes on until → (1) you have enough to buy the car
→ (2) you go bankrupt

what is the probability that you are eventually bankrupted?

$A =$ event that you go bankrupt

$B =$ first toss is a head

$$P_k(A) = P_k(A|B)P(B) + P_k(A|B^c)P(B^c)$$

denotes probability calculated with starting point "k"

$$P_k(A|B) = P_{k+1}(A), \quad P_k(A|B^c) = P_{k-1}(A)$$

Letting $P_k = P_k(A)$, we have

$$P_k = \frac{1}{2} P_{k+1} + \frac{1}{2} P_{k-1}, \quad 0 < k < N$$

$$P_0 = 1, \quad P_N = 0$$

Solving for P_k:

$$b_k = P_k - P_{k-1}, \quad b_{k-1} = P_{k-1} - P_{k-2}$$

$$b_k = b_{k-1}$$

$$P_k - P_{k-1} = P_{k-1} - P_{k-2}$$

$$2 \times P_{k-1} = P_k + P_{k-2}$$

$$P_{k-1} = \frac{P_k}{2} + \frac{P_{k-2}}{2}$$

So, $b_k = b_{k-1} = \cdots\cdots = b_1$

$$P_k = b_k + P_{k-1} = b_1 + P_{k-1}$$

$$= 2b_1 + P_{k-2}$$

$$= k b_1 + P_0$$

$$P_N = N b_1 + P_0$$

$$0 = N b_1 + 1$$

$$b_1 = -1/N$$

$$P_k(A) = P_k = 1 - \frac{k}{N}.$$

As $N \to \infty$, $P_k(A) \to 1$. $\blacksquare$

Example:

	Women		Men	
	Drug I	Drug II	Drug I	Drug II
Success	200	10	19	1000
Failure	1800	190	1	1000

Which drug is better?

Approach 1:

$$\text{Drug I} = \frac{219 \text{ cured}}{2020 \text{ given}}$$

$$\text{Drug II} = \frac{1010 \text{ cured}}{2200 \text{ given}}$$

So, drug II is better

Approach 2:-

Among men, $\text{Drug I} = \frac{19}{20}$, $\text{Drug II} = \frac{1}{2}$

Among women, $\text{Drug I} = \frac{1}{10}$, $\text{Drug II} = \frac{1}{20}$

So, drug I is better.

For more, read about Simpson's paradox.

Bayes' rule

$A_1, \ldots, A_n \rightarrow$ partition of Ω
B is an event with $P(B) > 0$

$$P(A_k | B) = \frac{P(A_k) P(B | A_k)}{\sum_{i=1}^{n} P(A_i) P(B | A_i)}$$

(Do your own proof)

Example: Rare disease $X \rightarrow$ affects 1 in 10^6

Medical test that is 99% accurate

i.e., Person has no X, chance of +ve = 1%

Person has X, chance of −ve = 1%

Suppose a person is tested for X & the result is +ve.

What is the (conditional) probability that he/she has X?

Let A = person has X

B = test gives +ve result

$P(A) = 10^{-6}$

$P(B/A) = 0.99$, $P(B/A^c) = 0.01$

$$P(A/B) = \frac{P(B/A)\,P(A)}{P(B/A)\,P(A) + P(B/A^c)\,P(A^c)}$$

$$= \frac{0.99 \times 10^{-6}}{0.99 \times 10^{-6} + 0.01\,(1 - 10^{-6})}$$

$\simeq 0.000099$

One way to look at this:

Population is 10^9 & 10^3 have X

Let all take test

Number of true +ves

$= 10^3 \times 0.99 \simeq 10^3$

Number of false positives

$= (10^9 - 10^3) \times 0.01 \simeq 10^7$

Among all +ves, false +ves $\gg$ true +ves