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Course Code: CS5402
Date: 22/12/2021

Solution 1) (i) $\forall w,h$: husband $(h,w) \Leftrightarrow$ Male $(h) \wedge$ Spouse $(h w)$

~~Mother~~ $\in$ husband $(x,y) \rightarrow x$ is husband of y

spouse $(x,y) \rightarrow x$ is spouse of y.

male $(x) \rightarrow x$ is a male.

ii) $\forall x$: Resturant $(x) \wedge \neg$ sells $(x$, popcorn$)$

$\forall y$: Cinema$(y) \wedge$ sells $(y$, popcorn$)$

Resturant (x) — x is Resturant

Cinema (x) — x is Cinema

Sells (x,y) — x sells y

iii) $\forall x \; \exists y$: Sibling $(x,y) \Leftrightarrow x \neq y \wedge$ parents $(p,x) \wedge$ parents (p,y)

Sibling (x,y) — x & y are Sibling.

parents $(p,x) \rightarrow p$ is parent of x.

iv) $\forall x$: Male$(x) \Leftrightarrow \neg$(Female (x))

v) $\neg\forall (x)$ (Student $(x) \rightarrow$ like$(x$, AI$) \wedge$ like $(x$, Compiler$))$

vi) $\forall x$: roman$(x) \rightarrow$ loyal (caesar, $x) \wedge \neg$ hated (caesar, x)

$\forall x$: roman $(x) \rightarrow \neg$ loyal (caesar, $x) \wedge$ hated (caesar, x)

vii) $\forall x, \forall y$: man $(x) \wedge$ ruler $(y) \wedge \neg$ loyal (x,y)

$\rightarrow$ try to assasinate (x,y)

viii) $\neg$ fail (1906055, AI)

fail $(x,y) \rightarrow$ Roll no. x failled in y subject

ix) $\forall x \; \forall y$: eat $(x,y) \wedge \neg$ killed $(x) \rightarrow$ food (y)

x) $\exists (x) \forall y$: topper $(x) \wedge$ backbencher $(y) \wedge$ Saves (x,y)

$\forall x$: backbencher $(x) \rightarrow$ hard working (x)

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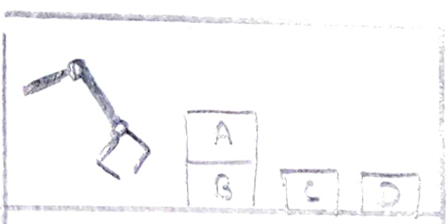
Solution 2)

Goal Stack Planning (GSP)

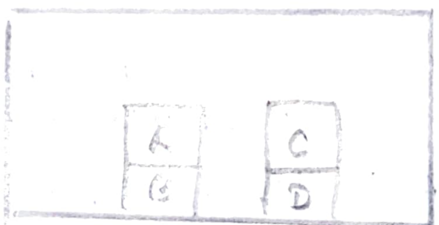
GSP is one of the oldest (earliest) methods in artificial intelligence in which we work backwards from the goal state to initial state. We start at the goal state and we try fulfilling the preconditions required to achieve the initial state.

Block World Problem.

In its basic form, the blocks world problem consists of cubes in same size which have all color black. A mechanical robot arm has to pick and place the cubes. More complicated derivatives of the problem consists of cubes in different sizes, shape and colors.



Initial State



Goal State

There is a table on which some blocks are placed, some blocks may be stack to other blocks. We have a robot arm to pickup or put down the blocks. The robot arm can move only one block at a time, and no other block should be stacked on the top of the block which is to be moved by the robot arm.

Our aim is to change the configuration of the blocks from initial state to Goal State.

- We start from the Goal State and we try fulfilling the pre conditions required to achieve the initial state.
- We keep on solving "goals" and "subgoals" to reach initial state

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- We make use of Stack to hold these goals that need to be fulfilled as well the actions that we need to perform for the same.

- Predicates: It can be thought of a statement which help we convey the information about a configuration in Block world.

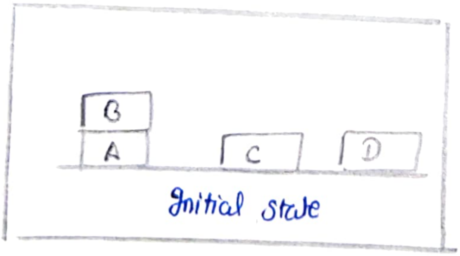
Predicate list with meaning:-

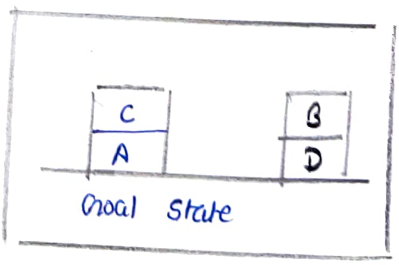
1. on(A,B) : block A is on B.
2. on TABLE(A) : A is on table.
3. Clear(A): Nothing is on top of A.
4. holding(A): Arm is holding A.
5. Armempty: Arm is holding nothing.

Using predicates:

Initial State.

on(B,A) ^ ontable(A) ^ on table(c) ^ on table(D) ^ Clear(B) ^ Clear(C) ^ Clear(D) ^ Arm empty.





Goal State

on(C,A) ^ on(B,D) ^ on table(A) ^ on Table(D) ^ Clear(B) ^ Clear(C) ^ Arm empty

Partial order plan.

A partial order plan or partial plan is a plan necessary which specifies all actions that need to be taken, but only specifies the order between the actions when necessary.

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→ A set of actions

→ A partial order for the actions. It specifies the conditions about the order of some actions.

→ A set of casual links. It specifies which actions meet which preconditions of other actions.

→ A set of open preconditions. It specifies which pre conditions are not fulfilled by any action in the partial order plan.

Conclusion- In order to keep the possible orders of the actions as open as possible orders of the action as ~~a~~, the set of order conditions and casual links must be as small as possible.

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Solution-3)

Goal-based agents:

These kind of agents take decision based on how far they are currently from their goal (description of desirable situations). The every action is intended to reduce its distance from the goal. This allows the agent a way to choose among multiple possibilities. Selecting the one which reaches goal state.

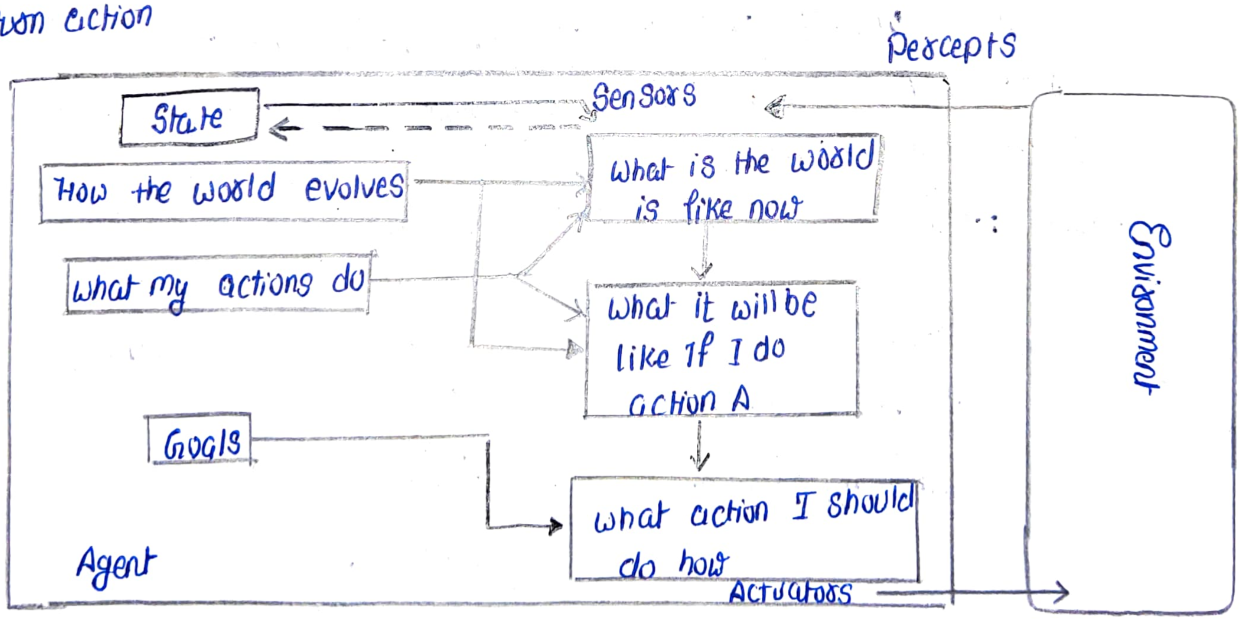
Function: Goal-Based Agent (percept) returns an action.
persistent: state, the agent's current conception of the world state.

state ← UPDATE STATE (state, action, percept, goal)

rule ← RULE-match (state, rules, goal)

action ← rule, action.

return action



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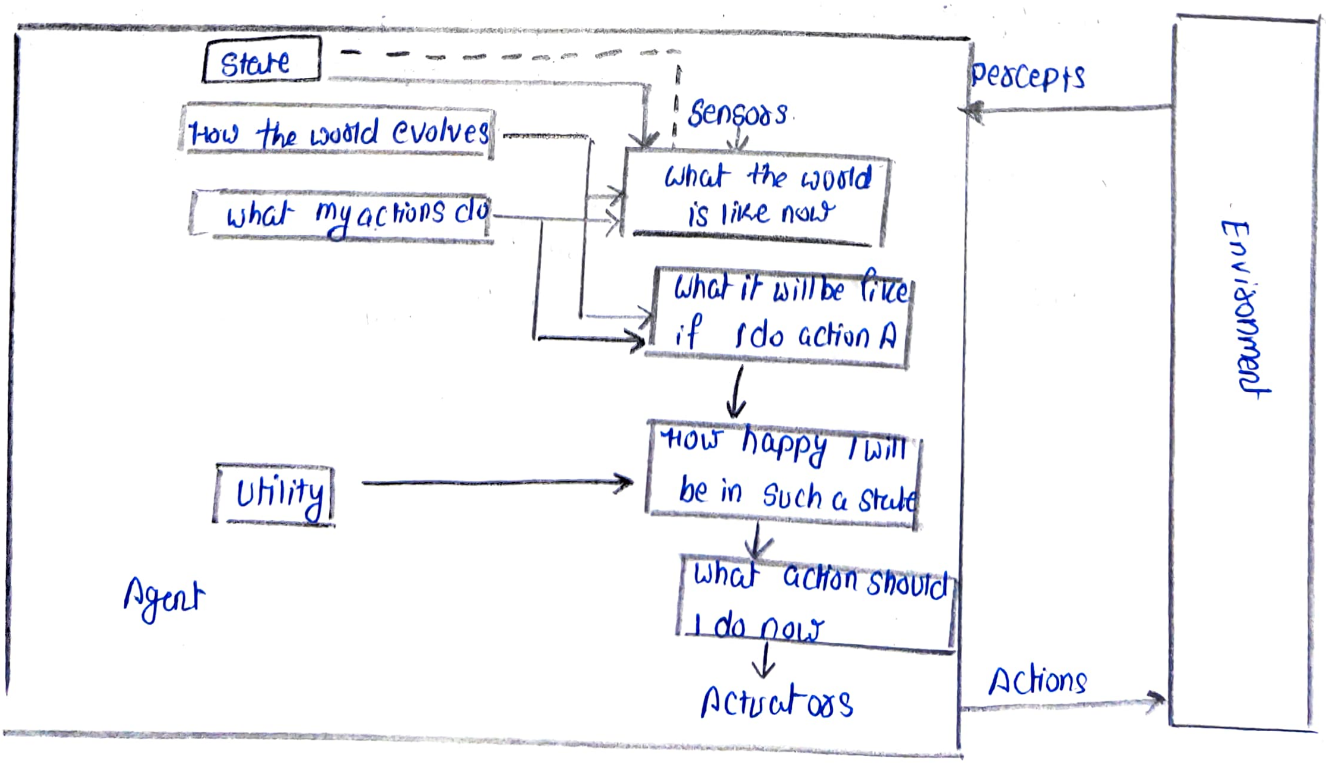
Solution 3> Continue... **Utility based agents:**

The agents which are developed having their end uses as building blocks are called utility agents. When there are multiple possible alternatives, then to decide which one is best, utility-based agents are used. They choose actions based on preference (utility) for each state. Sometimes achieving the desired goal is not enough. we may look for a quicker, safer, cheaper trip to reach a destination. Agent happiness should be taken into consideration.

function UTILITY-BASED-AGENT(percept) returns an action.
Persistent: state, the agent's current conception of the world state possible states, possible states that may maximize happiness. rules.
rules, a set of condition-action rules.
action, the most recent action, initially none

state ← UPDATE-STATE(state, action, percept, possible states)
rule ← RULE-MATCH(state, rules, Possible States)
action ← rule. ACTION
return action



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Solution 4: Propositional vs First-order logic:-

i> propositional logic converts a complete sentence, into a symbol and makes it logical whereas in first order logic relation of a particular sentence will be made that involves relations, constants, functions and constants

ii> The limitation of PL is that it does not represent any individual entities whereas FOL can easily represent the individual establishment that means if you are writing a single sentence then it can be easily represented in FOL.

iii> PL doesn't signify or expresses the generalization, specification or pattern for example 'QUANTIFIERS' cannot be used in PL but in FOL users can easily use quantifiers as it does express the generalization, specialization and pattern.

"The law says.... is American."

It is a crime for an American to sell weapons to hostile nations:

$$American(x) \wedge Weapon(y) \wedge Sells(x,y,z) \wedge Hostile(z)$$
$$\Rightarrow Criminal(x)$$

Nono has some missiles-

$$\exists x\ Owns(Nono, x) \wedge Missile(x)$$
$$Owns(Nono, M_1) \wedge Missile(M_1)$$

All of its missiles were sold to it by Colonel West

$$Missile(x) \wedge Owns(Nono, x) \Rightarrow Sells(West, x, Nono)$$

Missiles are weapons:

$$Missile(x) \Rightarrow Weapon(x)$$

An enemy of America counts as "Hostile";

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4> Continue... Missile (x) ^ owns (Nono, x) => Sells (west, x, Nono)

missiles are weapons.

Missile (x) => Weapon (x)

Enemy (x, America) => Hostile (x).

America (west)

A Forward Chaining proof:-

Step-1

| American (west) | missile (m1) | owns (Nano, m1) |
| | Enemy (Nono, America) | |

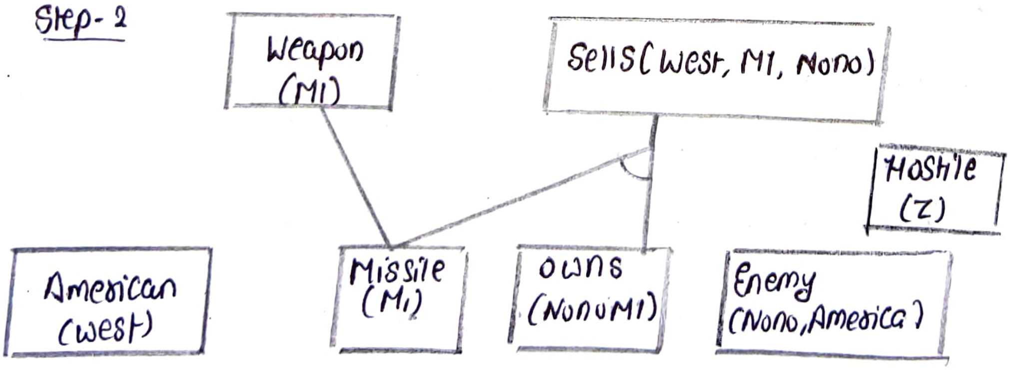
American (x) ^ Weapon (y) ^ Sells (x, y, z) ^ Hostile (z)
=> Criminal (x)

owns (Nono, m1) ^ missile (m1)

Missile (x) ^ owns (Nono, x) => Sells (west, x, Nono)

American (west) Enemy (Nono, America)

Step- 2



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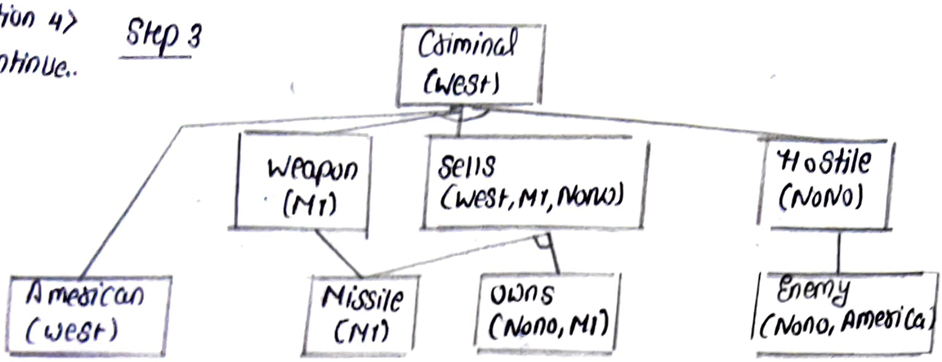
Solution 4) Continue..

Step 3



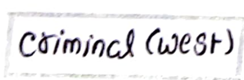
· Hence west is criminal using forward chaining approach.

Backward Chaining:

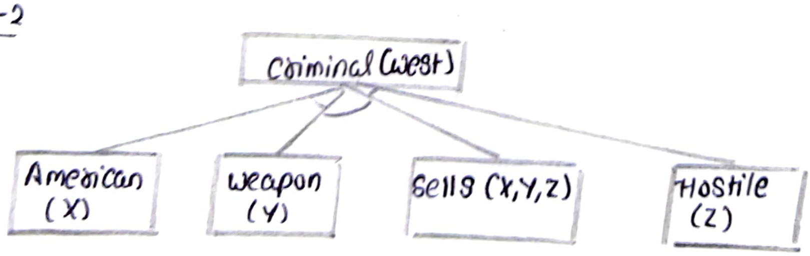
American(x) ∧ Weapon(y) ∧ Sells (x, y, z) ∧ Hostile (z)
=> Criminal (x)
owns (Nono, M1) ∧ Missile(M1)

Missile (x) ∧ owns (Nono, x) => Sells (west, x, Nono)
Missile (x) => weapon(x)
Enemy (x, America) => Hostile (x)
American (west)
Enemy (Nono, American)

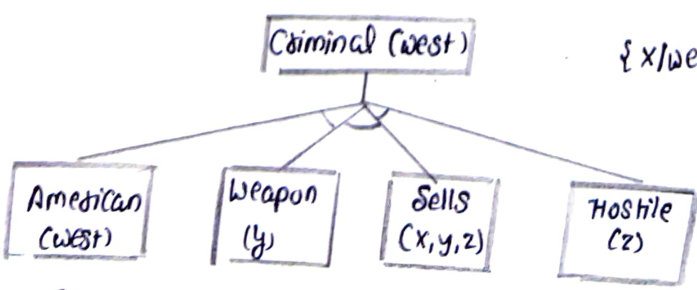
Step-1



Step-2



Step-3



{x/west}

{}

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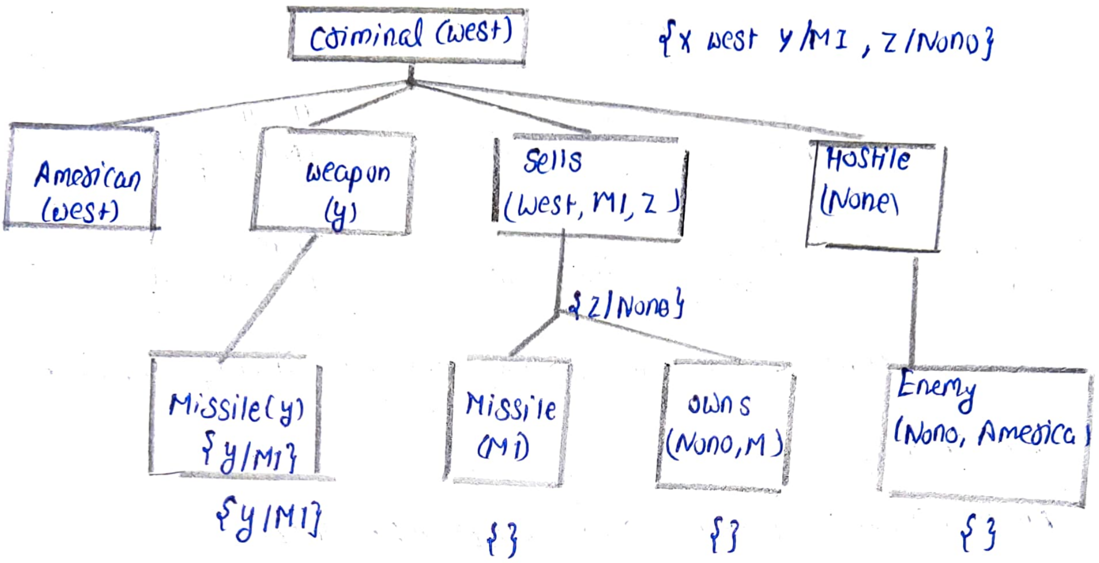
Solution 4)

Continue...



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Solution 5>

Solution A) A simple reflex agent can not be perfectly rational in this environment because the agent never stops and its score will continue downward. It also has no idea whether there are even any unclean spaces before moving

c) The following reasons are:-

- The vaccum cleaner agents keep moving forward and backward even after squares are clean.
- It is good to transfer No operation (NOOP) once square are clean.

Solution B) A reflex agent with a state is possible, as long as it keep track of environment, otherwise it will keep moving from space to space. But the reflex agent performs the same action in similar situations, so entering a dirty space and moving is fine, but after moving from a clean space it will continue to move forever. So as long as the agent has memory of squares and the environment it is possible to work. There needs to be a line of code that states "after all squares are clean stop."

b> Reflex agent with a state:

Percepts :- location and contents

Actions :- left , right stack

function :- SIMPLE - REFLEX - AGENT (percept) return as action.

Static :- rules, a set of conditions - actions - action rules.

State :- INTEREPT - INPUT (percept)

rule ← RULE - MATCH (state rule)

Action ← RULE - ACTION (rule)

return Action.

Solution c) If the agent knows whether a square is dirty or clean it has the option to take no action which prevents the score from decreasing. The agent should only clean dirty squares and if it has to travel a dirty space it should take the shortest route.

c). Consider an agent consists of smaller set of table with eight entries, indeed with percept sequence & necessary.

Percept Sequence	Action
[A, clean]	Right
[A, dirt]	Suck
[B, clean]	left
[B, dirty]	Suck
[A, clean] [A, clean]	Right
[A, clean] [A, dirty]	Suck

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Solution 7: The Bayes theorem describe the probability of an event based on the prior knowledge of the condition that might be related to the event.

If we know the conditional probability $P(A/B)$ we can use the Bays rule to find out reverse probability. $P(B/A)$.

$P(B/A)$.

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

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

$$P(A \cap B) = P(A/B) * P(B) = P(B/A) * P(A)$$

$$\left[P(B/A) = \frac{P(A/B) * P(B)}{P(A)} \right]$$

we can write the equation as

$$P(A_i/B) = \frac{P(B/A_i) * P(A_i)}{\sum_{i=1}^{n} P(B/A_i) \cdot P(A_i)}$$

Example: let's take example of cancer patients.

Senstivity (93%) - true positive rate

senstivity (99%) - true negative rate

P(has cancer / first test)

$P(\text{Cancer}) = 0.00148$

Senstivity or $P(+/\text{cancer}) = 0.93$

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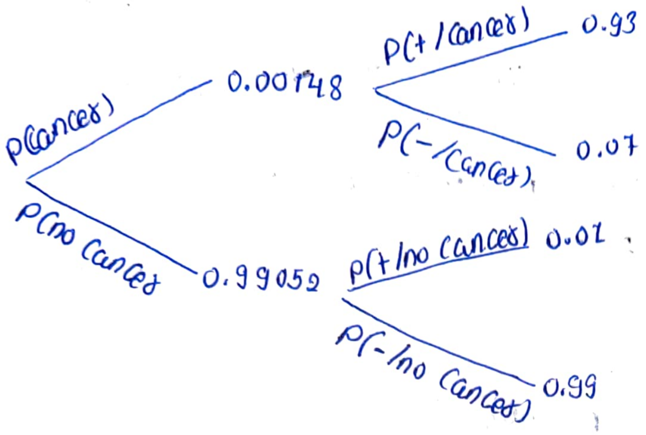

$$P(\text{cancer}/+) = \frac{P(\text{cancer and } +)}{P(\text{cancer and } +) + P(\text{No cancer and } +)}$$

$$= \underline{0.12}$$

The evidence

$$P(\text{observation}) = P(\text{hypothesis1, observation})$$
$$T2$$
$$T3$$
$$\vdots$$
$$P(\text{hypothesis 4, observation})$$

The numerator in Baye's theorem is one of the disjoint probabilitees.

The numerator is the evidence.

$$P(\text{hypothesis, observation}) = \frac{P(\text{hypothesis, observation})}{P(\text{observation})}$$

Since the evidence in denominator, Then Higher the evidence lower is the probability.