AI Exam Preparation

Unit 2

Reinforcement Learning

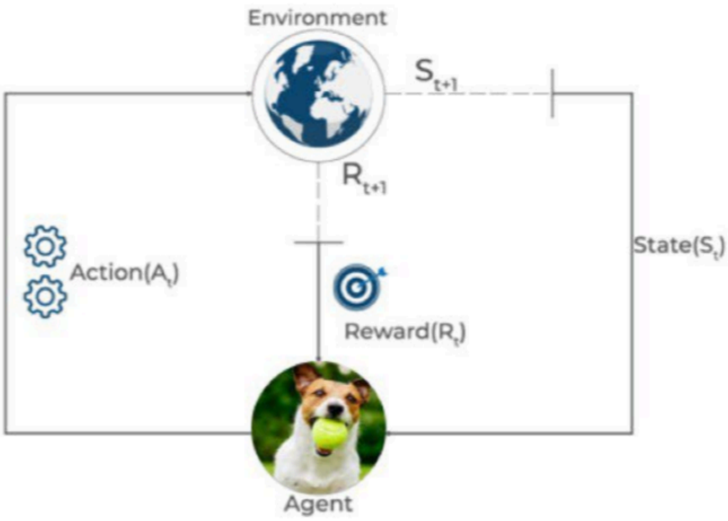


Figure 1: Reinforcement Learning

Rationality of Agent

Rationality of Agent depends on:

1. **Performance Measure**
2. Prior knowledge (Rememberence and **State**)
3. Possible actions agent can perform (**Actuators**)
4. Agent Perceptions (**Sensors** to perceive **Environment**)

PEAS Representation

Agents	Performance Measure	Environment	Actuators	Sensors
Vaccum Cleaner	Cleanness, Efficiency, Battery Lfe, Noise, Power	Room, Table, Wood floor, Vaccum Extractor	Wheels, Brushes, Vaccum Extractor	Camera, Dirt detection sensor, Cliff sensor, Bump Sensor, Infrared Wall Sensor

Types of Agent

Agent Type	**Memory**	**Goals**	**Learning**	**Suitable For**
Simple Replex Agent	⊠	⊠	⊠	Fully Observable, simple system
Model/Goal Based Agent	⊠	⊠	⊠	Partially Observable, goal driven
Learning Agent	⊠	⊠	⊠	Complex, dynamic, adaptive systems

Unit 3

State Space

Ω is the set of all possible configurations a system can be in while solving a problem.

States of a problem

1. Initial State
2. Goal State
3. Actions, (Rules for actions according to current state)
4. Search
   - Path Cost

Types of Searching

Uninformed	Informed
• Depth First Search (stack) • Breadth First Search (queue) • Depth Limit Search • Bidirectional Search	• Hill Climbing Search • Best First Search • Greedy Search • A^* Search

Breadth First Search

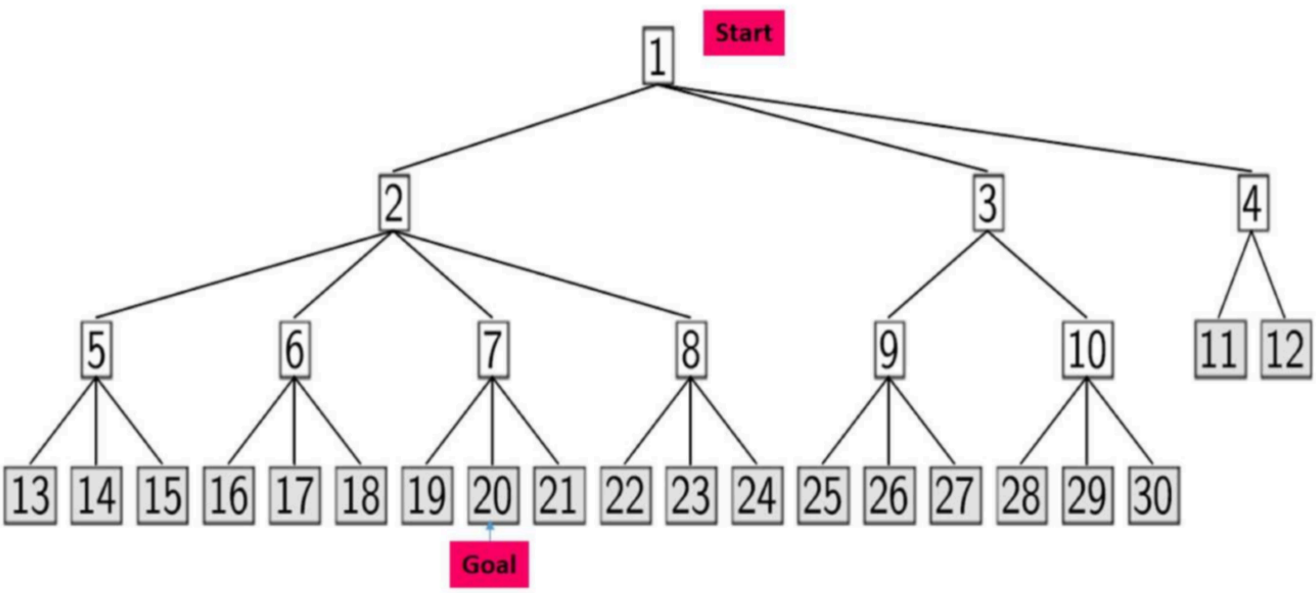


Figure 2: BFS and DFS Example

With BFS

Queue
1
2,3,4
3,4,5,6,7,8
4,5,6,7,8,9,10
5,6,7,8,9,10,11,12
6,7,8,9,10,11,12,13,14,15
7,8,9,10,11,12,13,14,15, 16,17,18
8,9,10,11,12,13,14,15,16,17,18,19,20,21
8,9,10,11,12,13,14,15,16,17,18,19,**20**
∴ 20 Found

With DFS:

Stack
1
4,3,2
4,3,8,7,6,5
4,3,8,7,6,15,14,13
4,3,8,7,6,15,14
4,3,8,7,6,15
4,3,8,7,6
4,3,8,7,18,17,16
4,3,8,7,18,17
4,3,8,7,18
4,3,8,7
4,3,8, 21, **20**
∴ 20 Found

Hill Climbing Search

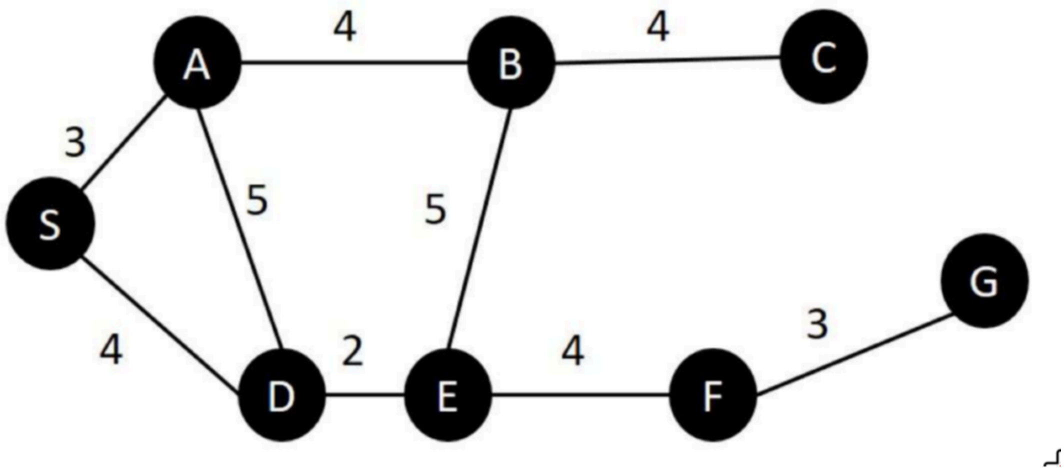


Figure 3: Hill Climbing Example

Sort the children cost in descending order then add to stack.

Stacks:

S	A	B	C	E	F	G
	D	D	E	D	D	D
			D			

Best First Search

There are two lists

- Open List (OL)
- Closed List (CL)

Step 1:
OL: S(NULL,0)
CL: NULL

Step 2:
OL: A(S,1), B(S,3), C(S, 10)
CL: [S]

Step 3:
OL: B(S,3), C(S,10), D(A,5+1=6)
CL: [S, A]

Step 4:
OL: C(S,10), D(A, 6), E(B, 3+4=7)
CL: [S, A, B]

Step 5:
OL: D(A, 6), E(B, 7)
CL: [S, A, B, C]
E(C, 16) > E(B, 7) so it is not taken.

Step 6:
OL: E(B, 7), F(D, 6+2=8)
CL: [S, A, B, C, D]

Step 7:
OL: F(D, 8), G(E, 6+7=14)
CL: [S, A, B, C, D, E]

Step 8:
OL: G(E, 14)
CL: [S, A, B, C, D, E, F]
F did not have any children

Step 9:
OL: ...
CL: [S, A, B, C, D, E, F, G]

G Found

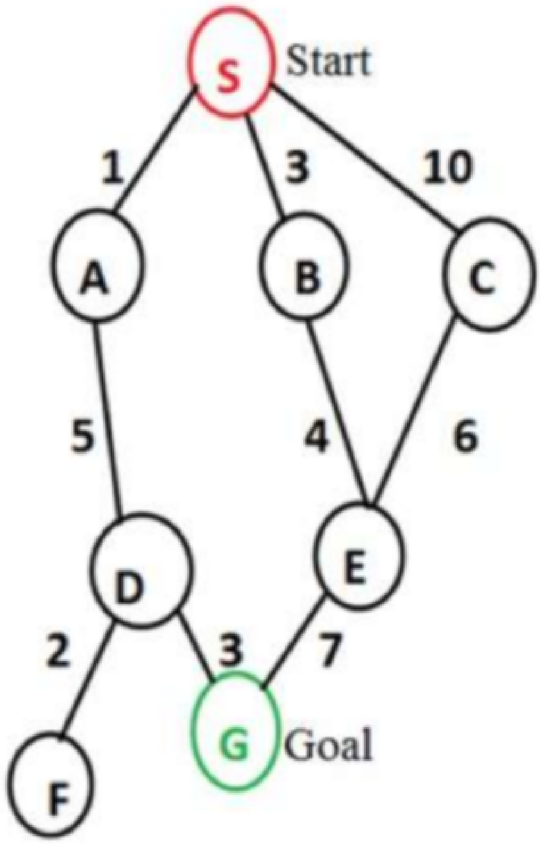


Figure 4: Best First Example

A^* Search Algorithm

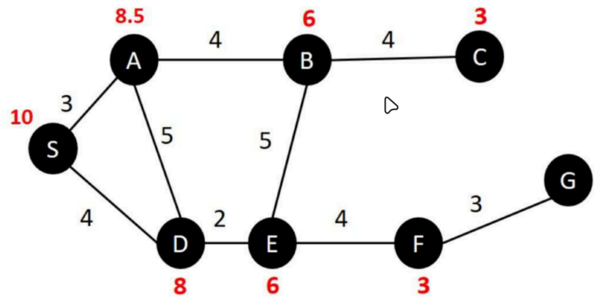


Figure 5: A^* Search Algorithm

Step 1:
We start with node **S**:
From **S** we can go to **A and D**
$f(\text{A}) = g(\text{A}) + h(\text{A}) = 3 + 8.5 = 11.5$
$f(\text{D}) = g(\text{D}) + h(\text{D}) = 4 + 8 = 12$

Here, $f(A) < f(D)$ so the path taken is:
$S \to A$

Step 2:
From **A** we can go to **D** and **B**.
$f(\text{D}) = g(\text{D}) + h(\text{D}) = 8 + 8 = 16$
$f(\text{B}) = g(\text{B}) + h(\text{B}) = 7 + 6 = 13$

Here, $f(B) < f(D)$ so the path taken is:
$S \to A \to B$

Step 3:
From **B** we can go to **E** and **C**
$f(\text{E}) = g(\text{E}) + h(\text{E}) = 12 + 6 = 18$
$f(\text{C}) = g(\text{C}) + h(\text{C}) = 11 + 3 = 14$

Here, $f(C) < f(E)$ so the path taken is:
$S \to A \to B \to C$

Step 4:
From **C** we cannot go anywhere. So we go to next node of **B** i.e. **E**
So, the path taken is:
$S \to A \to B \to E$

Step 5:
From **E**, we can go to **F** only, so the path taken is:
$S \to A \to B \to E \to F$

Again,
From **E** we can go to the goal node **G**.

So the final path is:
$S \to A \to B \to E \to F \to G$

Crypto Arithmetic Problem

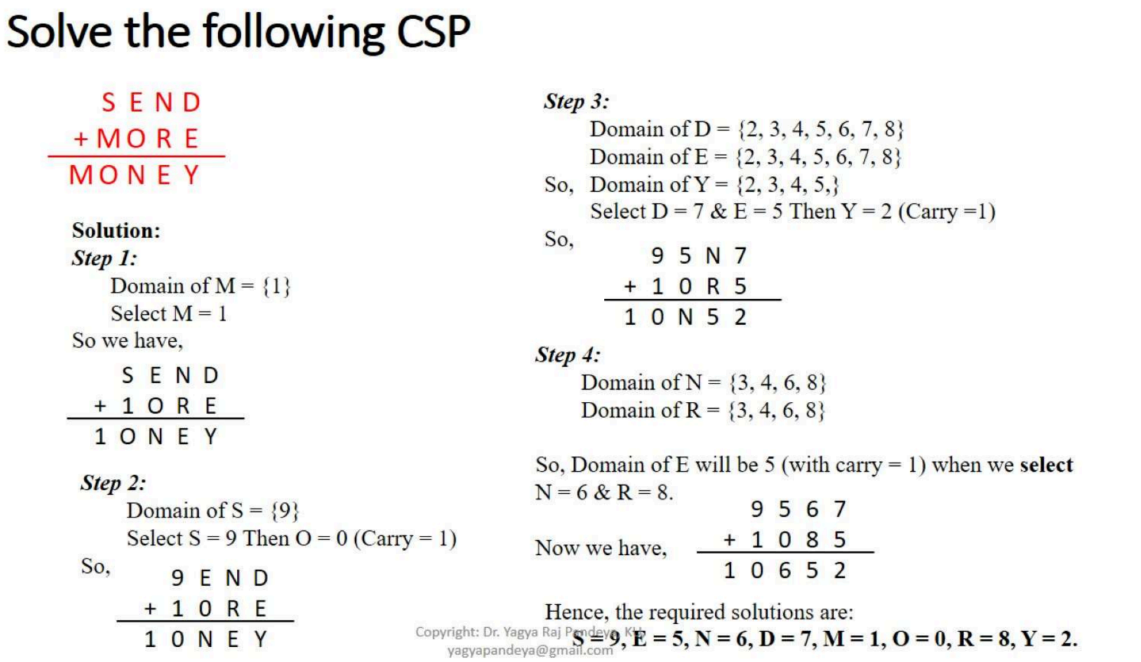


Figure 6: Send More Money

Alpha Beta Pruning

Here, α takes greater value and β takes less value only.

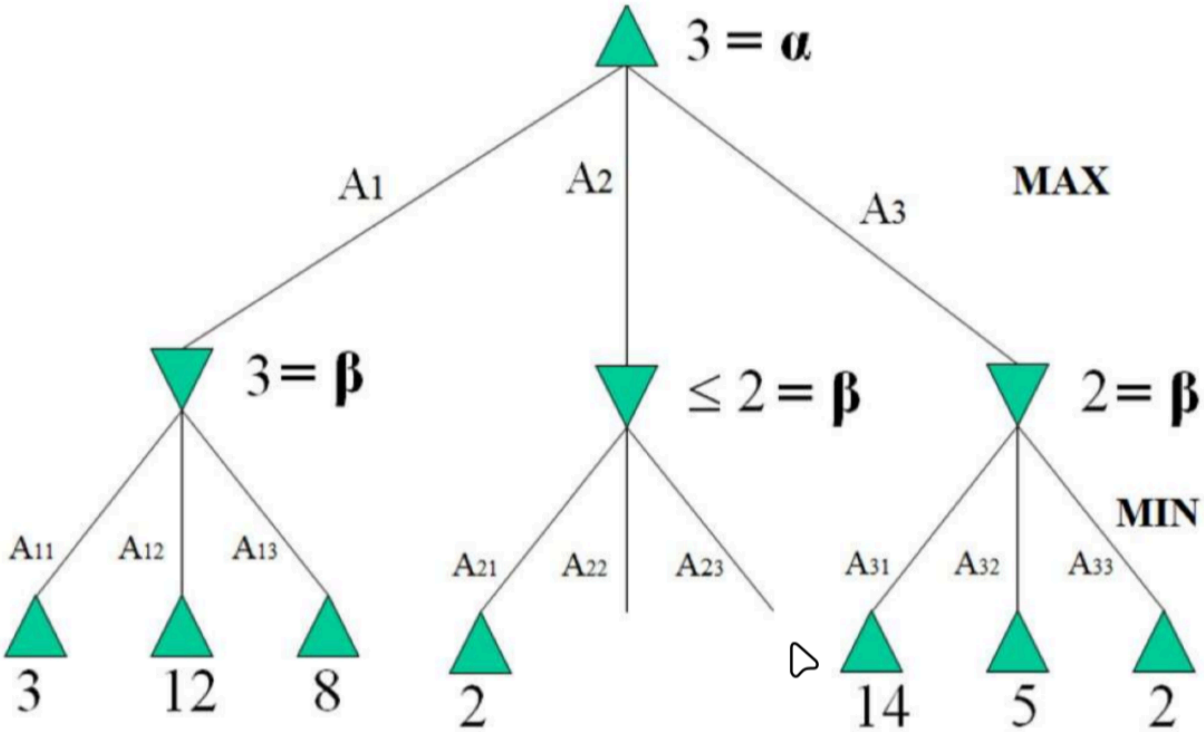


Figure 7: Alpha Beta Pruning

Rule of Inference	Tautology (Deduction Theorem)	Name
P Premise $\therefore P \vee Q$ Conclusion	$P \rightarrow (P \vee Q)$	**Addition**
$P \wedge Q$ $\therefore P$	$(P \wedge Q) \rightarrow P$	**Simplification**
P Q $\therefore P \wedge Q$	$[(P) \wedge (Q)] \rightarrow (P \wedge Q)$	**Conjunction**
P $P \rightarrow Q$ $\therefore Q$	$[(P) \wedge (P \rightarrow Q)] \rightarrow Q$	**Modus Ponens**
$\neg Q$ $P \rightarrow Q$ $\therefore \neg P$	$[(\neg Q) \wedge (P \rightarrow Q)] \rightarrow \neg P$	**Modus Tollens**
$P \rightarrow Q$ $Q \rightarrow R$ $\therefore P \rightarrow R$	$[(P \rightarrow Q) \wedge (Q \rightarrow R)] \rightarrow (P \rightarrow R)$	**Hypothetical Syllogism ("chaining")**
$P \vee Q$ $\neg P$ $\therefore Q$	$[(P \vee Q) \wedge (\neg P)] \rightarrow Q$	**Disjunctive syllogism**
$P \vee Q$ $\neg P \vee R$ $\therefore Q \vee R$	$[(P \vee Q) \wedge (\neg P \vee R)] \rightarrow (Q \vee R$	**Resolution**

Figure 8: Rules of Inference

$$
\begin{aligned}
(\alpha \wedge \beta) &\equiv (\beta \wedge \alpha) \quad \text{commutativity of } \wedge \\
(\alpha \vee \beta) &\equiv (\beta \vee \alpha) \quad \text{commutativity of } \vee \\
((\alpha \wedge \beta) \wedge \gamma) &\equiv (\alpha \wedge (\beta \wedge \gamma)) \quad \text{associativity of } \wedge \\
((\alpha \vee \beta) \vee \gamma) &\equiv (\alpha \vee (\beta \vee \gamma)) \quad \text{associativity of } \vee \\
\neg(\neg \alpha) &\equiv \alpha \quad \text{double-negation elimination} \\
(\alpha \Rightarrow \beta) &\equiv (\neg \beta \Rightarrow \neg \alpha) \quad \text{contraposition} \\
(\alpha \Rightarrow \beta) &\equiv (\neg \alpha \vee \beta) \quad \text{implication elimination} \\
(\alpha \Leftrightarrow \beta) &\equiv ((\alpha \Rightarrow \beta) \wedge (\beta \Rightarrow \alpha)) \quad \text{biconditional elimination} \\
\neg(\alpha \wedge \beta) &\equiv (\neg \alpha \vee \neg \beta) \quad \text{De Morgan} \\
\neg(\alpha \vee \beta) &\equiv (\neg \alpha \wedge \neg \beta) \quad \text{De Morgan} \\
(\alpha \wedge (\beta \vee \gamma)) &\equiv ((\alpha \wedge \beta) \vee (\alpha \wedge \gamma)) \quad \text{distributivity of } \wedge \text{ over } \vee \\
(\alpha \vee (\beta \wedge \gamma)) &\equiv ((\alpha \vee \beta) \wedge (\alpha \vee \gamma)) \quad \text{distributivity of } \vee \text{ over } \wedge
\end{aligned}
$$

Figure 9: Logical Equivalence

Example of Inference

Example-2: "If you send me an e-mail message then I will finish writing the program", "If you do not send me an e-main message then I will go to sleep early", and "If I go to sleep early then I will wake up feeling refreshed". Lead to the conclusion "If I do not finish writing the program then I will wake up feeling refreshed".

Solution: Let

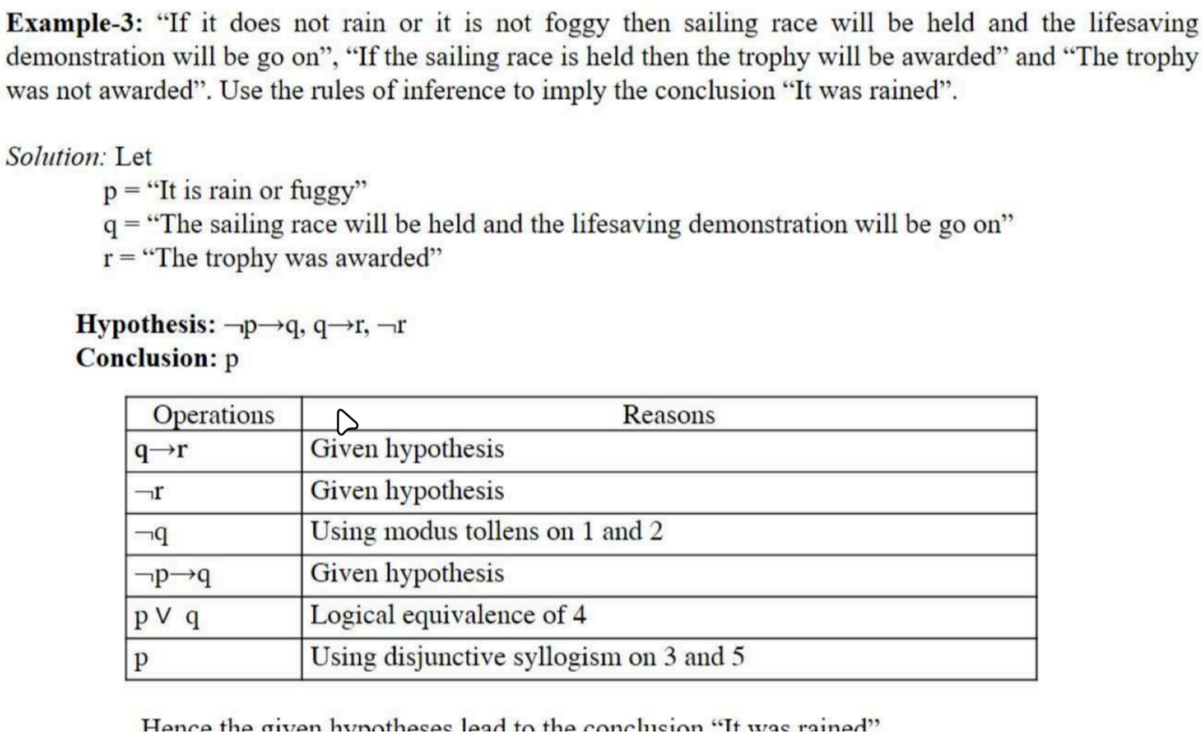
p = "You send me an e-mail message"
q = "I will finish writing the program"
r = "I will go to sleep early"
s = "I will wake up feeling refreshed"

Hypothesis: $p \to q$, $\neg p \to r$, $r \to s$
Conclusion: $\neg q \to s$

Operations	Reasons
$p \to q$	Given hypothesis
$\neg q \to \neg p$	Using contrapositive on 1
$\neg p \to r$	Given hypothesis
$\neg q \to r$	Using hypothetical syllogism on 2 and 3
$r \to s$	Given hypothesis
$\neg q \to s$	Using hypothetical syllogism on 4 and 5

Hence the given hypotheses lead to the conclusion $\neg q \to s$.

Figure 10: Inference Example 1



Example-3: "If it does not rain or it is not foggy then sailing race will be held and the lifesaving demonstration will be go on", "If the sailing race is held then the trophy will be awarded" and "The trophy was not awarded". Use the rules of inference to imply the conclusion "It was rained".

Solution: Let

p = "It is rain or fuggy"
q = "The sailing race will be held and the lifesaving demonstration will be go on"
r = "The trophy was awarded"

Hypothesis: $\neg p \rightarrow q$, $q \rightarrow r$, $\neg r$
Conclusion: p

Operations	Reasons
$q \rightarrow r$	Given hypothesis
$\neg r$	Given hypothesis
$\neg q$	Using modus tollens on 1 and 2
$\neg p \rightarrow q$	Given hypothesis
$p \vee q$	Logical equivalence of 4
p	Using disjunctive syllogism on 3 and 5

Hence the given hypotheses lead to the conclusion "It was rained"

Figure 11: Inference Example 2

Resolution

Make all hypothethis to ∨ and add $\boxed{\perp}$ (empty clause) to hypothesis.

Example-2: Let

$\varphi 1 = A \vee B \vee \neg D$
$\varphi 2 = A \vee B \vee C \vee D$
$\varphi 3 = \neg B \vee C$
$\varphi 4 = \neg A$
$\varphi = C$

The task is show that $\{\varphi 1, \varphi 2, \varphi 3, \varphi 4, \neg\varphi\} \models_{Res} \perp$

1. $A \vee B \vee \neg D$ [hypothesis φ1]
2. $A \vee B \vee C \vee D$ [hypothesis φ2]
3. $A \vee B \vee C$ [res. on 1, 2 with ¬D, D]
4. $\neg B \vee C$ [hypothesis φ3]
5. $A \vee C$ [res. on 3, 4 with B, ¬B]
6. $\neg A$ [hypothesis φ4]
7. C [res. on 5, 6 with A, ¬A]
8. $\neg C$ [hypothesis ¬φ]
9. $\perp$ [res. on 7, 8]

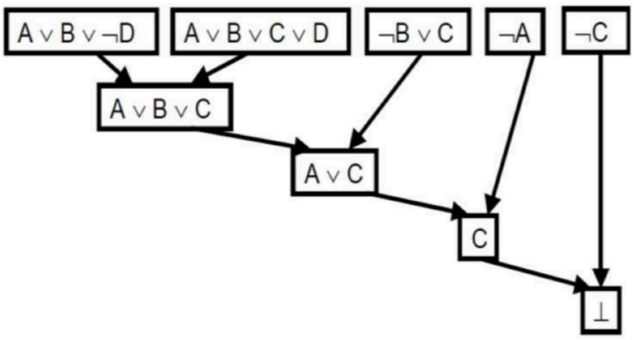


Figure 12: Resolution

FOPL

For all x Roman x typeshit.

Unit 5

Machine Learning Life Cycle

1. Data Preprocessing
2. Feature Engineering
3. Model Training
4. Model Evaluation
5. Model Deployment
6. Model Serving
7. Model Monitoring

Information processing pipeline

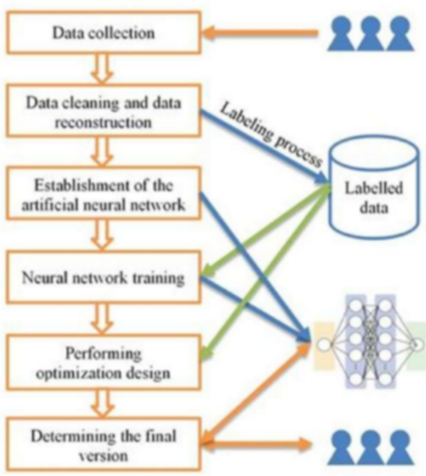


Figure 13: Information Processing Pipeline

Components of ML

- Data
- Model
- Features
- Labels (Target)
- Learning Algorithm
- Optimization
- Testing
- Regularization
- Evaluation Metrics
- Validation
- Training Process
- Testing

What to do when you have less data? How do you manage data scarcity?

- Data Augmentation

Data Visualization Objectives

- Understand data distribution
- Explore relationships
- Detect anamolies
- Feature Selection
- Model Interpretation

Data Privacy Methods

- Transfer Learning
- Differential Privacy
- Homomorphic Encryption
- Federated Learning