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05/05

Page No.
Date 30.-

ASSIGNMENT - I

Q1) What is AI & considering the COVID-19 pandemic situation, how AI helped to survive and renovated our way of life with different applications?

⇒ Artificial Intelligence (AI) enables machines to think, learn and make decisions like humans. It includes technologies like machine learning, NLP & robotics.

Applications:

1) Healthcare: AI helped in early diagnosis, vaccine development, and chatbot-based health assitance.
2) Contact Tracing: AI-powered apps tracked COVID-19 exposure ensuring public safety.
3) Remote work & Education: AI enhanced virtual meetings, online learning & productivity tools.
4) Supply chain & Delivery: AI optimized logistics & enabled autonomous deliveries.
5) Mental Health Support: AI-driven apps provided emotional & fitness assistance.

Q2) What are AI Agents terminology, explain with examples.

⇒ 1) Agent: An entity that interacts with the environment & makes decision based on inputs.
ex: A self-driving car perceives traffic signals & adjusts speed accordingly.

2) Performance measures: Defines how successful an agent is in achieving its goal.
ex: A self-driving car's performance measures could be minimizing accidents, fuel efficiency & travel time.

3) Behavior/Action of Agent: The action an agent takes based on its percepts.
ex: A robotic vaccuum cleaner moves around obstacles after detecting them.

4) Percept: The data an agent receives at a specific moment from sensors.
ex: A spam filter receives an email & detects keywords, sender info, and attachments.

5) Percept sequence: The entire history of percepts received by an agent.
ex: A chess playing AI remembers all previous moves in the game before making its next move.

6) Agent Function: A mapping from the percept sequence to an action.
ex: A smart thermostat analyzes past tempreture changes & adjusts heating accordingly.

Q3) How AI technique is used to solve 8-puzzle problem?
⇒ It consists of a 3x3 grid with 8 numbered tiles & one empty space, where the objective is to move the tiles around to match a predefined goal configuration.

Initial State:

1	2	3
4		6
7	5	8

This is the random starting configuration of the 8 puzzle with the tiles placed in a non-goal configuration.

2> Goal state : The goal is to arrange the tiles in a specific order with the blank space at the bottom right.

Goal State

1 2 3
4 5 6
7 8

* Solving the 8 Puzzle problem.

- AI search algorithms, such as breadth-first search (BFS), depth-first search (DFS) and A*, are commonly used :

1> Breadth-First Search (BFS):

- BFS is an uninformed search algorithm that explores all possible state level by level, starting from the initial state.
- BFS guarantees that the solution found is the shortest in terms of number of moves, but it can be very slow.

Advantages:

Guaranteed to find the optimal solution.

Disadvantages:

BFS has a high memory requirement, as it must store all the states at each level of exploration.

2> Depth-First Search (DFS):

- DFS is another uninformed search algorithm that explores one branch of the state space tree as deep as possible before backtracking.

Advantages:

DFS is more memory-efficient than BFS.

Disadvantages:

DFS can get stuck in deep, non-optimal paths & may not find the shortest solution.

Steps using A*:
- Compute Manhattan distance for each possible move.
- Choose the best move (lowest F(n))
- Repeat until reaching the goal state.

Q4) What is PEAS descriptor ? Give PEAS descriptor for following

1) Taxi driver:
- P : Minimize travel time, fuel efficiency, passenger safety, obey traffic rules.
- E : Roads, traffic, passengers, weather, obstacles, pedestrians
- A : Steering, accelerator, brakes, turn signals, horn.
- S : Camera, GPS, speedometer, radar, LiDAR, microphone

2) Medical Diagnosis System:
- P : Accuracy of diagnosis, treatment success rate, response time
- E : Patient records, symptoms, medical tests, hospital database
- A : Display screen, printed prescriptions, notifications
- S : Patient input, lab reports, electronic health records

3) A music Composer:
- P : Quality of music, adherence to genre, audience engagement.
- E : Digital workspace, music production software, real time composition settings.
- A : Audio output, digital instrument selection, file saving/export
- S : User inputs, style preferences, tempo, feedback from listners, music theory contraints.

4) An aircraft Autolander:
P: Smooth landing, accuracy in reaching runway, passenger safety, fuel efficiency
E: Airspace, runway, weather, wind speed, visibility
A: Flight control, landing gears, brakes
S: GPS, airspeed indicator, gyroscope, radar, weather sensors

5) An essay Evaluator
P: Accuracy of grading, consistency, fairness, grammer
E: Digital text input, student essays, predefined grading criteria
A: Feedback generation, score assignment, ~~hand~~ highlighting errors, suggesting improvement.
S: Optical character recognition, NLP, grammer & spell checkers.

6) A robotic sentry gun for the keck lab.
P: Target accuracy, threat detection efficiency, response speed,
E: keck lab premises, intruders, lighting conditions, obstacles
A: Gun aiming system, firing mechanism, camera panning, alert system
S: Motion detectors, infrared sensors, cameras, LIDAR, radar

Q5) Categorize a shopping bot for an offline bookstore according to each of six dimension (fully/partially observable, determinstic/stochastic, episodic/sequential, static/dynamic, discrete/continuous, single/multi agent)

⇒ 1) Partially Observable: The bot may not have complete visibility.
2) Stochastic: The enviroment is unpredictable.
3) Sequential: Each decision bot makes affects future states
4) Dynamic: The bookstore environment changes over time
5) Discrete: Bot choose discrete choices (selecting books)
6) multi agent: The bot interacts with multiple entities.

Page No.
Date

Q6) Differentiate Model based & Utility based agent

⇒

Model Based Agent	Utility Based Agent
1) Maintains an internal model of the environment to make decision.	1) Uses a utility function to measure performance & make option choices.
2) Relies on stored knowledge & updates the model.	2) Chooses actions based on maximizing expected utility.
3) Can adapt to changing environment by updating the internal model.	3) More flexible & goal-oriented, adapting to changes dynamically.
4) Moderate complexity due to model maintainance.	4) Higher complexity due to the need to compute utilities for different actions.
5) Ex: Self-driving car that predicts pedestrian movement	5) A self driving car that evaluates & routes & selects the best one.

Q7) Explain the architecture of a knowledge based agent & learning Agent.

⇒ 1. Knowledge-Based Agent Architecture

- A knowledge-based agent is an intelligent that makes decisions using knowledge base (KB) and reasoning machanism.

Architecture Component:

1) knowledge base: Stores fact, rules & heuristics about the world.
2) Inference Engine: Use logical reasoning (FOL) to derive new knowledge from the KB.
3) Perception Module: Collects data from sensor & update the KB.
4) Action selection Module: Chooses appropriate actions based on reasoning outcomes.

5) Communication Module: Allows interaction with other agents

Working Process:

- The agent perceives the environment & updates its KB.
- The interference engine applies logical rules to infer new knowledge.
- The agent decides on action and executes it.
- The KB is continuously updated to improve decision-making.

2) learning Agent Architecture:

- A learning agent improves its performance over time by learning from past experiences & interactions with the environment

Architecture: components:

1) Learning Element: Analyzes feedback from the environment and improves knowledge.
2) Performance Element: Make decisions & executes actions.
3) Critic : Evaluates the agent's action & provides feedback.
4) Problem Generator: Suggests explatory actions to improve learning.

Working Process:

- The performances element selects an action.
- The critic evaluates the action & provides feedback
- The learning element updates the agents knowledge to improve future decisions.
- The problem generator suggests new strategies to explore better solutions.

Page No.
Date

Q8) What is AI? Considering the COVID-19 pandemic situation, how AI helped to survive & renovated our way of life with different applications?

⇒ • Artifical Intelligence (AI) is the simulation of human intelligence in machines that can learn, reason & make decision. AI system process large datasets, recognize patterns & automate tasks, enhancing efficiency across institutes.

AI's role in the COVID-19 pandemic:

1) Healthcare & Diagnosis: AI analyzed CT scans & detected COVID-19 faster.

2) Chatbots & virtual assistants: Provided instant medical advice.

Q9) Convert the Following to predicates:

a) Anita travels by car if available otherwise travels by bus.

⇒

carAvailable → Travel by Car (Anita)

¬ Car Available → Travel By Bus (Anita)

b) Bus goes via Andheri and Goregaon.

goesVia (Bus, Andheri) ∧ ~~Goregaon~~ goesVia (Bus, Goregaon)

c) Car has punture & is not available

Puncture (car) → ¬ ~~car~~ Available (car)

Q) Will anita travel via Goregaon

From (c):

Punture (car) is true, punture (car) → ¬ Available (car)

For (a):

¬ carAvailable → Travel By Bus (Anita)

From b:

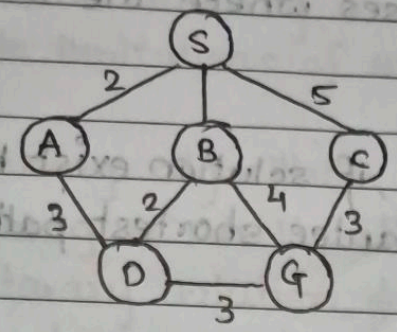
Goes via (Bus, Goregaon)

∴ Anita will travel via goregaon.

Galaxy S24

Page No.
Date

Q10) Find the route from S to G using BFS.



Current Node	Queue	Visited node
~~S~~	A B C	S
~~A~~	B C	

~~Step 1:~~

~~Selecting least cost between (A,2) (B~~

Current Node	Queue	Visited Node.
S	A B C	S
~~A~~	B C D G	S→A
B	C D G	S→A→B
C	D G	S→A→B→C
D	G	S→A→B→C→D
G		S→A→B→C→D→G

Path S→A→B→C→D→G

Q11) What do you mean by depth limited search? Explain iterative Deepening search with example.

→ Depth-Limited Search (DLS):

• Depth-Limited Search (DLS) is a variation of Depth-First Search (DFS) where the search is limited to a predefined depth. This helps prevent the algorithm from going too deep into the search tree

avoiding infinite loops in cases where the tree is unbounded.

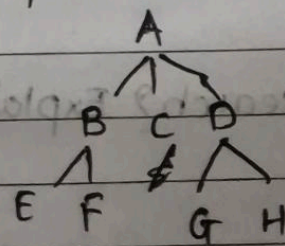
Key features:
1) Completeness: Not complete, if solution exist beyond depth limit.
2) Optimality: Doesn't guarantee shortest path.
3) Time Complexity: $O(b^d)$
4) Space Complexity: $O(b \times L)$

- When the search space is large or infinite
- If you know the appropriate depth where the solution may lie.

* Iterative Deepening Search (IDS):
- Iterative Deepening Search is a combination of DFS & BFS. It performs a series of Depth-limited searches with increase depth limits until a solution is found. This combines the space efficiently of DFS & the completeness of BFS.

Key Features:
1) Completeness: Yes, it will find solution if it exists.
2) Optimality: Yes, if unweighted.
3) Time Complexity: $O(b^d)$
4) Space Complexity: $O(b \times d)$

Example



1) Depth 0: Explore [A] → No solution.
2) Depth 1: Explore [A, B, C, D] → No solution.
3) Depth 2: Explore [A, B, C, D, E, F, G, H] → Solution found at H

Page No.
Date

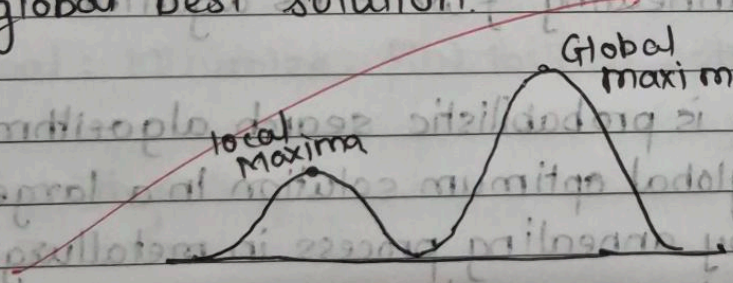
Q.12) Explain Hill Climbing and its drawbacks in detail with example Also state limitations of steepest-ascent hill climbing.

⇒

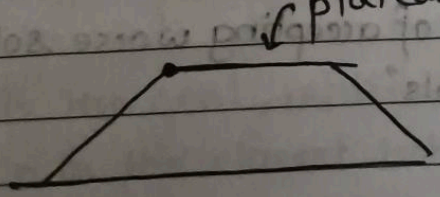
Hill climbing algorithm:
Hill climbing is an iterative search algorithm that starts with an arbitrary solution & makes small changes to improve it. The goal is to reach the optimal solution by continuously moving toward better states.
It is a local search algorithm that evaluates the neighbouring states & moves to the best one.

Types of hill climbing:
1) Simple hill climbing
2) Steepest-Ascent Hill climbing
3) Stochastic Hill climbing.

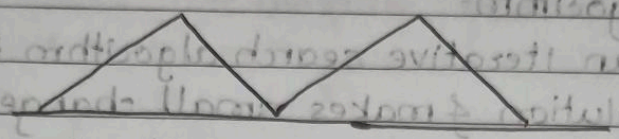
* Drawbacks of Hill Climbing:
1) local Maxima: Gets stuck at a peak that is not the global best solution.



2) Plateau: A flat region where all neighbouring values are the same, preventing progress.



3> Ridges: Steep paths where small moves are ineffective because the goal lies along a narrow ridge.



* Limitation of steepest-Ascent Hill climbing:

1> Increased Time complexity: Evaluating all neighbors requires more computation time.

2> local Optima: It can still stuck in local maxima, just like simple hill climbing.

3> Plateau Issue: Can't move forward if all neighbour have same value.

4> No backtracking: The algorithm can't revisit earlier states, even if a better solution lies there.

Q13> Explain simulated annealing & write its algorithm.

⇒

- Simulated annealing is probabilistic search algorithm used to find an appropriate global optimum solution in a large search space. It is inspired by annealing process in metallurgy, where metals are heated & slowly cooled to reduce defects & improve structure.
- Unlike hill climbing, which only moves to better solution, simulated annealing allows occasional moves to worse solutions to escape local optima. The probability of accepting worse solutions decrease over time as the system "cools".

Page No.
Date

Algorithm:
1) Initial solution: S
2) Initial tempreture: T
3) Cooling rate α
4) Cost function f(s)
5) Stopping Condition (min tempreture).

Q14) Explain A* Algorithm with an example.

⇒ A* algorithm is a widely used search algorithm in AI for finding the shortest path between two points. It is an informed search algorithm that combines the strengths of both Uniform Cost Search and Greedy Best-first Search.

A* evaluates each nodes using the following cost function.

$$f(n) = g(n) + h(n)$$

Where:
f(n) ⇒ Total estimated cost to reach the goal through node n.
g(n) ⇒ Actual cost from the start node to node n.
h(n) ⇒ Heuristics estimate of the cost from node n to the goal.

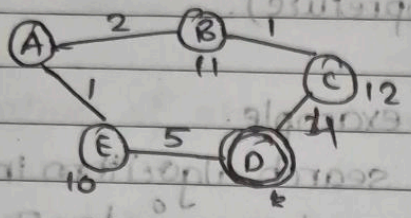
Goal: Minimize f(n) to find optimal path.

Algorithm Steps:
1) Initialize
- Open list (to track nodes to be explored)
- Closed list (to track explored nodes).

2) Add the start node to the open list.
3) Repeat until Goal is found.
- Select the node n from the open list with lowest f(n).
- IF n is the goal, return the path.
- Move n to the closest list.

- For each neighbour of n:
  - If the neighbour is in the closet list, skip it
  - If the neighbour is not in the open list, add it
  - Update the g, h and f values.

4) Return failure if no path is found



Start node: A

$A \rightarrow B \Rightarrow f(n) = g(n) + h(n)$

$= 2 + 11$

$= 13$

$A \rightarrow E \Rightarrow f(n) = g(n) + h(n)$

$= 1 + 10$

$= 11$

Select

$A \rightarrow E \rightarrow D = f(n) = g(n) + h(n)$

$= 1 + 5 + 0$

$= 6$

$A \rightarrow B \rightarrow C \Rightarrow f(n) = g(n) + h(n)$

$= 2 + 1 + 12$

$= 15$

$A \rightarrow B \rightarrow C \rightarrow D \Rightarrow f(n) = g(n) + h(n)$

$= 2 + 1 + 4$

$= 7$

Shortest path $A \rightarrow E \rightarrow D$ cost = 6

Page No.
Date

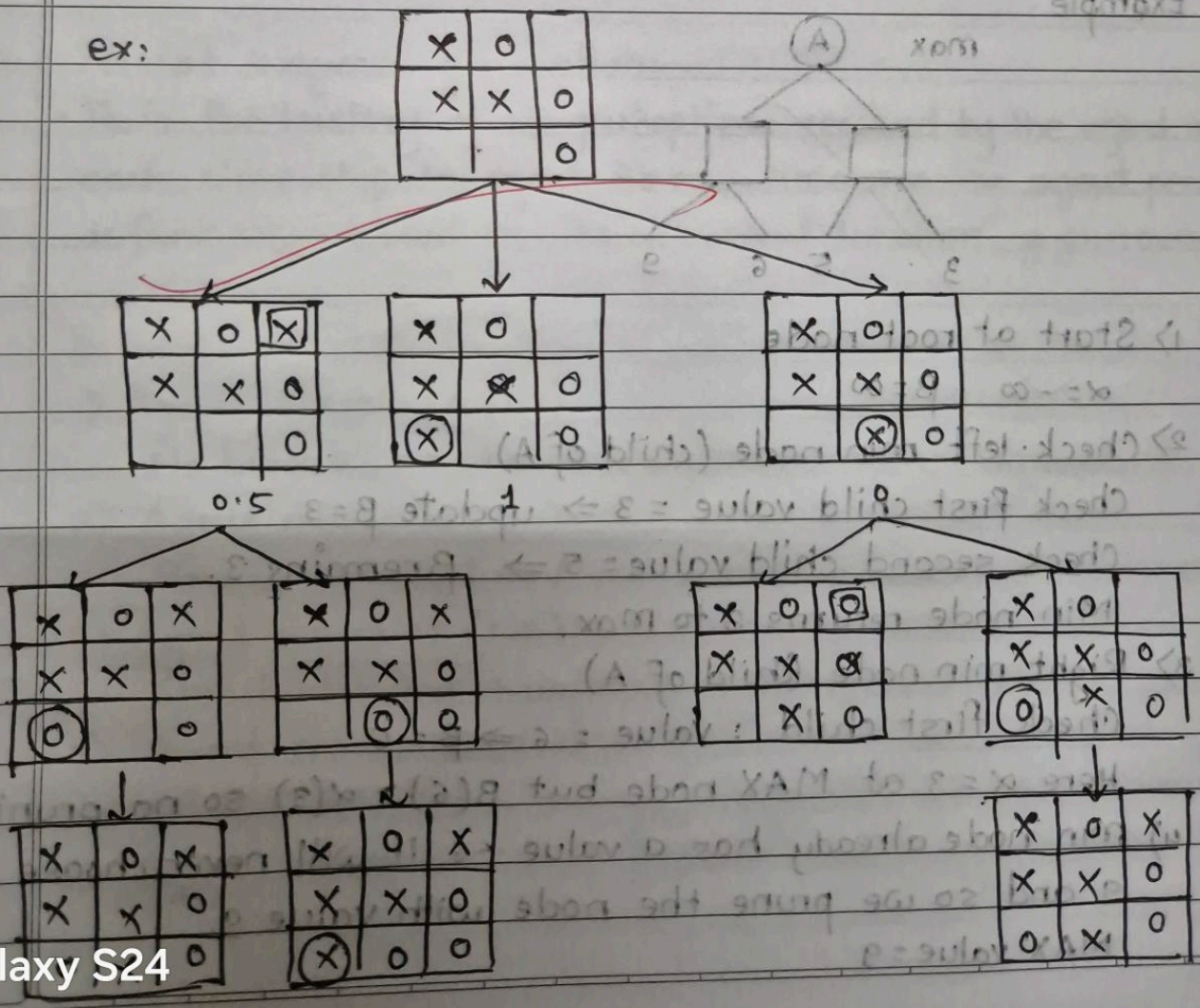
Q15) Explain min-max algorithm & draw game tree for tic-tac-toe game

⇒ • The min-max algorithm is a decision making algorithm used in 2 player games. It assumes one player [MAX] tries to maximize to score & other tries to minimize the score.

Algorithm:

1) Generate game tree.
2) Assign scores
3) MAX picks highest value from children
   MIN picks lowest value.
4) Repeat until root node is evaluated starting a bottom up aproach.

ex:

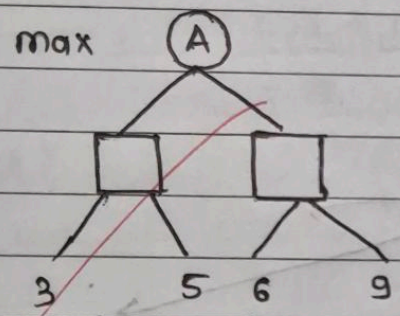


Q16) Explain alpha beta pruning algorithm for adversial search with example

⇒ Alpha beta pruning is an optimization technique used in minimax algorithm to reduce the number of nodes evaluated in adversial search problems like game playing AI (eg: chess).

Alpha beta pruning includes
Alpha (α): The best maximum score that the maximizing player can guarantee so far.
Beta (β): The best minimum score that the minimizing player can guarantee so far.

Example



1) Start at root node
$\alpha = -\infty$ $\beta = \infty$

2) Check left min node (child of A)
Check first child value = 3 ⇒ update $\beta = 3$
Check second child value = 5 ⇒ β remains 3.
Min node returns 3 to max.

3) Right min node (child of A)
Check first child : value = 6 ⇒ $\beta = 6$
Here $\alpha = 3$ at MAX node but $\beta(6) > \alpha(3)$ so no pruning.

4) min node already has a value ≤6 it will never choose 9 and so we prune the node with value 9.
MAX value = 9

Page No.
Date

Q17) Explain WUMPAS world environment, giving its PEAS description. Explain how percept sequence is generated.

⇒ • The WUMPUS World environment is a simple grid-based environment used in AI to study intelligent agent behaviour.
• In uncertain environment, it is a turn based environment where an agent must navigate a case to find gold while avoiding hazards like pits & a monster called wumpas.

PEAS:

P: Grabbling gold, exit safely, Do not fall into pit.
E: 4x4 grid, agent, wumpus, pits, gold.
A: Move left, right, shoot, forward
S: Breeze (near pit), glitter (near gold), lump.

Percept sequence generation:

• It is the history of all perceptions received by the agent at each time step, ~~the agent~~ At each time step the agent perceives information based on its ~~as~~ current location & surrounding.

Example:

1) Agent starts at (1,1)
No breeze, no stench, no glitter → safe square.
2) Agent moves to (2,1)
Breeze detected → A pit is near but not on same square.
3) Agent moves at (1,2):
Stench detected → wumpus is in adjacent cell.
4) Agent moves to (2,2):
Glitter detected → ~~wumpus is in adjacent~~ gold is near.
5) Agent moves back to (1,1) & climbs out.

Q18) Solve for crypt Arithematic

SEND + MORE = MONEY

⇒ Step 1:

m=1 (Sum of 4 digit is 5 digit therefore carry from 4th digit).

```
  S E N D
  1 0 R E
---------
1 0 N E Y
```

Step 2:

~~Assume:~~

~~E+0 = 10+N~~ Since carry is generated for 5th digit

~~then~~

S+1 = 0+10

This is possible only if 9=9 ∴ 9+1 = 0+10

0=0

```
  9 E N D
+ 1 0 R E
---------
1 0 N E Y
```

Step 3:

E + 0 = N (This is not possible as E ≠ N)

∴ E + 0 + ~~N = 10~~

lets assume

E = 5

∴ N = 5 + 1 (carry)

N = 6

```
  9 5 6 0
+ 1 0 R 5
---------
1 0 6 5 Y
```

Page No.
Date

$6 + R = E + 5$

$\therefore R = 8$

$6 + 9 = 5 + 10$

$$\begin{array}{r} 9\ 5\ 6\ D \\ +\ 1\ 0\ 8\ 5 \\ \hline 1\ 0\ 6\ 5\ Y \end{array}$$

$D + 5 = Y$

We have $\{2, 3, 4, 7\}$ options left.
Since $(2, 3, 4)$ can't generate carry

$\therefore$ If $D = 7$

$$\begin{array}{r} 9\ 5\ 6\ 7 \\ +\ 1\ 0\ 8\ 5 \\ \hline 1\ 0\ 6\ 5\ 2 \end{array}$$

$\therefore$ Final solution

$S = 9$
$E = 5$
$N = 6$
$D = 7$
$M = 1$
$O = 0$
$R = 8$
$Y = 2$

Q19) Consider the following axioms.

- All people who are graduating are happy, All happy people are smiling, someone is graduating

⇒

Representing these axioms in first order predicate logic.

$G(x)$ = x is graduating.
$H(x)$ = x is happy
$S(x)$ = x is smiling

Translating axiom into predicate logic.

1) All people who are graduating are happy.

$\forall x : G(x) \rightarrow H(x)$

2) All happy people are smiling

$\forall x : H(x) \rightarrow S(x)$

3) Someone is graduating

$\exists (x)\ G(x)$

Convert each formula to clause form

1. Convert implication to clausal form.

$\forall x\ G(x) \rightarrow H(x)$

- Using implication removal

$\forall x\ (G(x) \vee H(x))$

- In clause form

$\{\neg H(x), H(x)\}$

2. $\forall(x) : H(x) \rightarrow S(x)$

- Using implication removal

$\forall x (\neg H(x) \vee S(x))$

- In clausal form

$\{\neg H(x), S(x)\}$

3. $\exists x G(x)$

- In clausal form : $\{G(x)\}$

Prove " is something using resolution

1) Collect clauses

1) $\{\neg G(x), H(x)\}$
2) $\{\neg H(x), S(x)\}$
3) $\{G(x)\}$

2) Apply resolution

- Resolve (1) $\{\neg G(x), H(x)\}$ with $\{G(x)\}$

Substituting $x = a$

$\{\neg G(a), H(a)\}$

$\therefore$ we have $G(a)$, resolving gives $\{H(a)\}$

- Resolve (2) $\{\neg H(x), S(x)$ with $\{H(a)\}$

Substituting $x = a$

$\{\neg H(a), S(a)\}$

- Since, we have $H(a)$, resolving given

$\{S(a)\}$

Since, we derived $S(a)$, we conclude that someone (a) is smiling.

Page No.
Date

Q20) Explain modus ponen with suitable example.

⇒ Modus ponen is a fundamental rule of interference in propositional logic that follows us to deduce a conclusion from a conditional statement & its antecedant.

It follows the form

1) $P \rightarrow Q$ (If P then Q)

2) P (P is true)

$\therefore Q$ (Q must be true)

Example:

1) If it is cold, you wear sweater

$P \rightarrow Q$

2) It is cold $\rightarrow P$

$\therefore$ You wear sweater Q

Q21) Explain forward and backward chaining algorithm with the help of example.

⇒ Forward Chaining: It starts with given facts and applies inference rules to derive new facts until the goal is reached. It is a data driven approach because it begins with known data & work forward to react a conclusion.

Ex: Diagnosing a disease.

Rules:

1) If a person has fever & cough they might have flu.

2) If a person has sore throat and fact, they might have cold

Facts:

1) The patient has a fever

2) The patient has cough.

Page No.
Date

Inference

1) Fever + cough → flu (rule 1 applies)
2) Conclusion, the patient might have flu.

Backward Chaining:

It starts with goal & works to backward by checking what facts are needed to support it. It is a goal driven approach

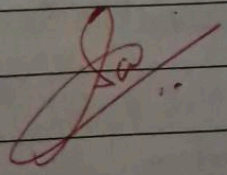
Example : Diagonising a disease
Goal: Determine if patient has flu.

Rules:

1) Fever ∧ cough → flu
2) Sour throat ∧ fever → Cold

Process:

1) We want to prove flu.
2) Looking at rule 1 : [Fever ∧ cough] → flu, we need to check if patient has fever & cough.
3) We check our known facts.
   - Patients has fever
   - Patient has cough.
4) Since, both conditions are met, we confirm flu is true.



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Q.1: Use the following data set for question 1
82, 66, 70, 59, 90, 78, 76, 95, 99, 84, 88, 76, 82, 81, 91, 64, 79, 76, 85, 90

1. Find the Mean (10pts)
2. Find the Median (10pts)
3. Find the Mode (10pts)
4. Find the Interquartile range (20pts)

Answer:

1. Mean : Mean is the sum of all numbers divided by the total count.

   Total Sum = 82 + 66 + 70 + 59 + 90 + 78 + 76 + 95 + 99 + 84 + 88 + 76 + 82 + 81 + 91 + 64 + 79 + 76 + 85 + 90
   Total Sum = 1621
   N = 20

   Mean = Total sum / N= 1621 / 20 = 81.05

   Mean = 81.05

2. Median: Median is the middle value in an ordered list.

   Sort the data:
   59, 64, 66, 70, 76, 76, 76, 78, 79, 81, 82, 82, 84, 85, 88, 90, 90, 91, 95, 99

   Since n = 20,
   Therefore, median = average of 10th and 11th number
   Median = (81 + 82) / 2 = 81.5

   Median = 81.5

3. Mode: Mode is the number that appears most frequently.

   76 appears 3 times that is maximum than other

   Mode = 76

4. Interquartile Range (IQR):

   Step 1: Sort the data:
   59, 64, 66, 70, 76, 76, 76, 78, 79, 81, 82, 82, 84, 85, 88, 90, 90, 91, 95, 99

   Divide it into 2 halves

Step 2: First half (1st to 10th):
59, 64, 66, 70, 76, 76, 76, 78, 79, 81

Median of the first half:

5th and 6th values: 76 and 76
Q1 = (76 + 76)/2 = 76

Step 3: Second half (11th to 20th):
82, 82, 84, 85, 88, 90, 90, 91, 95, 99

Median of the second half:
5th and 6th values: 88 and 90
Q3 = (88 + 90)/2 = 89

Step 4:
IQR = Q3 − Q1 = 89 − 76 = 13

Interquartile Range (IQR) = 13

Q.2 1) Machine Learning for Kids

Target Audience:

- Students (typically in middle or high school).
- Teachers and educators introducing artificial intelligence (AI) and machine learning (ML) in classrooms.
- Beginners with little or no coding background.

Use by Target Audience:

- Students upload or input examples of text, numbers, or images and assign labels (e.g., happy/sad, dog/cat).
- The tool uses these examples to train a machine learning model.
- Students can then test the model and see how well it predicts new data.
- They can build fun projects using Scratch or Python that include their ML models — like games that respond to emotional messages or quizzes that react to images.

Benefits:

- Kid-friendly interface using blocks (Scratch) and easy menus.
- Makes ML interactive, fun, and creative for young learners.
- No need to install anything — it runs on the web.
- Encourages logical thinking and digital creativity.

Drawbacks:

- Only covers basic concepts — can't handle complex data science tasks.
- Performance is limited — not suitable for large datasets or real-world deployment.
- Relies on a working internet connection.

Predictive or Descriptive Analytic:

I will choose predictive analytics and reasons for this are:

- The tool learns from past labeled data and predicts a label for new input (e.g., predicting the emotion of a sentence).
- Example: "I am so excited!" → Model predicts: Happy.
- This prediction of future or unknown input classifies it as predictive, not just summarizing past data.

Supervised / Unsupervised / Reinforcement Learning:

I will chose Supervised Learning because:

- Users provide labeled training data (e.g., "I love ice cream" → Happy).
- The model learns based on those labels.
- Example: After training, the model is asked to predict the label for a new sentence — and it uses its supervised learning to respond.

2) Teachable Machine

Target Audience:

- Students, hobbyists, and beginners interested in building AI projects quickly.
- Teachers and presenters who want to demonstrate AI concepts in an interactive way.
- Content creators who want to integrate AI into web or app projects without writing code.

Use by Target Audience:

- Users can train models using images, sounds, or poses by providing multiple labeled examples.
- The tool then creates a machine learning model based on these examples.
- Users can test the model live (e.g., showing their face or speaking) and download/export the model for use in apps, websites, or games.

Benefits:

- No coding needed — just click, record, and train.
- Great for visual learners — everything happens in real-time and is easy to understand.
- Supports exporting to TensorFlow.js, Unity, or other platforms for real projects.
- Works well for quick experiments and demos.

Drawbacks:

- Limited control over how the model is trained (can't tweak algorithms or settings).
- Performance decreases with too many classes or very complex data.
- Requires webcam, mic, and internet access for most features.

Predictive or Descriptive Analytic:

I will choose predictive analytics and reasons for this are:

- It predicts what a user is doing or saying based on trained data.
- For example: If the model sees you doing a thumbs-up, it predicts "Like".
- The focus is on forecasting/classifying new data, not just summarizing — hence, Predictive Analytic.

Supervised / Unsupervised / Reinforcement Learning:

I will chose Supervised Learning because:

- The user supplies labeled data (each image or sound is tagged).
- The model learns from these examples to make predictions.
- Example: You label 10 "Hello" gestures and 10 "Stop" gestures — the system uses this to recognize them later. That's supervised learning.

NAME: Bhushan Malpani DIV: D15C ROLL NO: 33

Q.3 Data Visualization: Read the following two short articles:

- Read the article Kakande, Arthur. February 12. “What’s in a chart? A Step-by-Step guide to Identifying Misinformation in Data Visualization.” *Medium*
- Read the short web page Foley, Katherine Ellen. June 25, 2020. “How bad Covid-19 data visualizations mislead the public.” *Quartz*
- Research a current event which highlights the results of misinformation based on data visualization. Explain how the data visualization method failed in presenting accurate information. Use newspaper articles, magazines, online news websites or any other legitimate and valid source to cite this example. Cite the news source that you found.

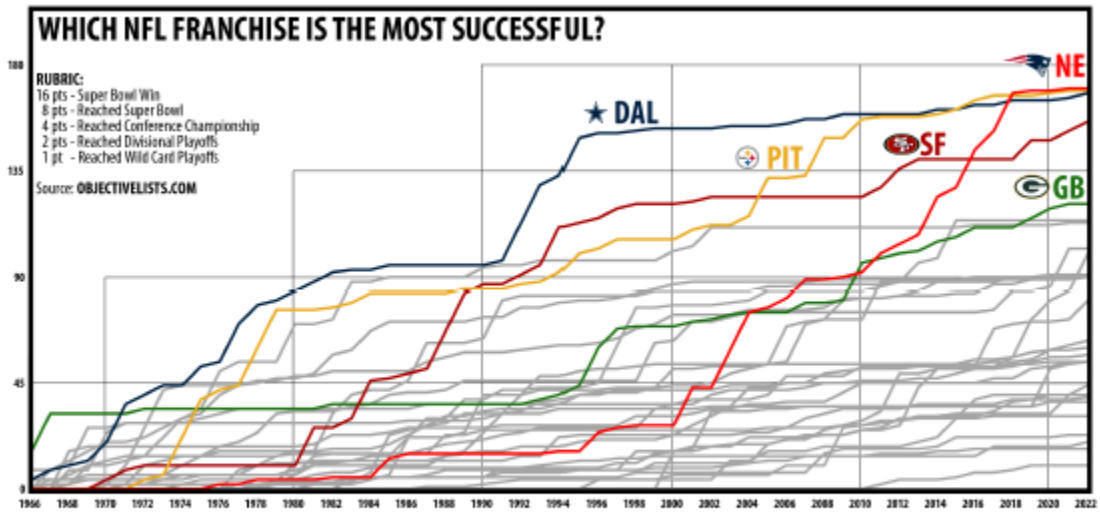


Fig. 8. Contrived metric

Based on the research paper "Misinformative Data Visualizations in the Sports Media Domain" by Drew Scott, I can identify several examples of how data visualizations can mislead readers, specifically in sports media.

One particularly interesting example from the paper is Figure 8, labeled as "Contrived Metric." The author identifies this as a case where a visualization creates a metric without an objective basis, which leads to questionable narratives. This type of misinformation is particularly problematic because it gives the appearance of scientific rigor while actually presenting subjective or arbitrary measurements. The paper categorizes this under "Lie with Statistics" in the Input stage of visualization, and notes that this was one of the most common issues found in their corpus (14 instances).

NAME: Bhushan Malpani DIV: D15C ROLL NO: 33

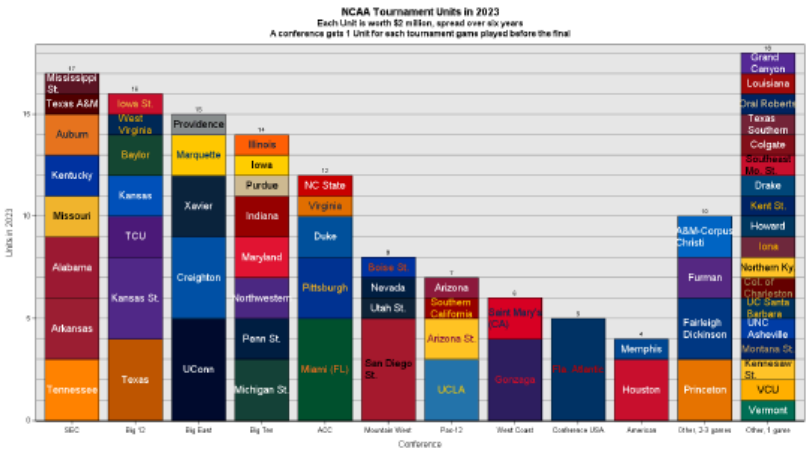


Fig. 3. Stacked bar chart for college basketball conference data

This relates to a current event from March 2023, when ESPN released a "Championship Leverage Index" during the NCAA basketball tournament that purported to show which teams had the most favorable paths to winning. The visualization used a complex formula combining multiple metrics that hadn't been validated, and presented the results as objective analysis. Several sports analysts, including those at The Athletic, criticized the visualization for creating a seemingly scientific metric that actually incorporated significant subjective weighting, leading fans to misunderstand team strengths. The contrived nature of the metric wasn't adequately explained, yet the presentation with precise decimal values and professional graphics gave it an air of authority.

The visualization failed by creating what Scott would categorize as a "Contrived Metric" - a transformation applied to otherwise good data without an apparent or well-explained objective basis. This is particularly misleading because casual viewers typically trust data presented in visual form, especially when it comes from established media outlets. Without proper explanation of methodology or limitations, such visualizations can significantly shape public perception based on questionable analytical foundations.

The paper effectively demonstrates that the sports media domain, despite being considered more "lighthearted" than domains like public health or politics, still exhibits numerous examples of misinformative visualizations that can significantly impact public understanding of the subject matter.

Cite as: Drew Scott. Misinformative Data Visualizations in the Sports Media Domain. *TechRxiv.* April 03, 2024.

DOI: 10.36227/techrxiv.171216651.10279711/v1

NAME: Bhushan Malpani DIV: D15C ROLL NO: 33

Q. 4 Train Classification Model and visualize the prediction performance of trained model required information

Pima Indians Diabetes Database

Dataset link: https://www.kaggle.com/datasets/uciml/pima-indians-diabetes-database

Dataset Description: Pima Indians Diabetes

This dataset contains medical diagnostic information of women of Pima Indian heritage, aged 21 and above. The goal is to predict whether a patient has diabetes based on several health-related measurements.

Feature Descriptions

- **Pregnancies**: Number of times the patient has been pregnant
- **Glucose**: Plasma glucose concentration (mg/dL) after 2 hours in an oral glucose tolerance test
- **BloodPressure**: Diastolic blood pressure (mm Hg)
- **SkinThickness**: Skin fold thickness (mm)
- **Insulin**: 2-Hour serum insulin (mu U/ml)
- **BMI**: Body Mass Index (weight in kg / height in m²)
- **DiabetesPedigreeFunction**: A score showing the likelihood of diabetes based on family history
- **Age**: Age of the patient (in years)
- **Outcome**: Target variable — `0` = No diabetes, `1` = Has diabetes

NAME: Bhushan Malpani DIV: D15C ROLL NO: 33

Step 1: Data loading

```
import pandas as pd
import numpy as np
from sklearn.model_selection import train_test_split, GridSearchCV
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import classification_report, confusion_matrix, accuracy_score, ConfusionMatrixDisplay
from sklearn.naive_bayes import GaussianNB
from sklearn.svm import SVC
from imblearn.over_sampling import SMOTE
import matplotlib.pyplot as plt
import seaborn as sns
```

```
[2] df = pd.read_csv('/content/diabetes.csv')
    df.head()
```

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DiabetesPedigreeFunction	Age	Outcome
0	6	148	72	35	0	33.6	0.627	50	1
1	1	85	66	29	0	26.6	0.351	31	0
2	8	183	64	0	0	23.3	0.672	32	1
3	1	89	66	23	94	28.1	0.167	21	0
4	0	137	40	35	168	43.1	2.288	33	1

Step 2: Data preprocessing:

```
# Features and label
X = df.drop('Outcome', axis=1)
y = df['Outcome']

# Handle missing values in features (replace zeros with NaN where invalid)
cols_with_zero = ['Glucose', 'BloodPressure', 'SkinThickness', 'Insulin', 'BMI']
X[cols_with_zero] = X[cols_with_zero].replace(0, np.nan)

# Fill NaNs with mean values
X = X.fillna(X.mean())

# Feature scaling
scaler = StandardScaler()
X_scaled = scaler.fit_transform(X)
```

Step 3: Handle Class Imbalance

```
from imblearn.over_sampling import SMOTE

# Apply SMOTE
smote = SMOTE(random_state=42)
X_resampled, y_resampled = smote.fit_resample(X_scaled, y)
```

We used SMOTE (Synthetic Minority Over-sampling Technique) to balance the dataset.
It creates synthetic examples of the minority class by interpolating between existing ones.
This helps prevent the model from being biased toward the majority class during training.

Step 4: Train, Validation and Test Split should be 70/20/10, Train and Test split must be randomly done:

```
# First split (10% test)
X_train_val, X_test, y_train_val, y_test = train_test_split(
    X_resampled, y_resampled, test_size=0.10, random_state=42, stratify=y_resampled)

# Second split (20% of remaining for validation)
X_train, X_val, y_train, y_val = train_test_split(
    X_train_val, y_train_val, test_size=2/9, random_state=42, stratify=y_train_val)

print(f"Train: {X_train.shape}, Validation: {X_val.shape}, Test: {X_test.shape}")
```

```
Train: (700, 8), Validation: (200, 8), Test: (100, 8)
```

Step 5: Train SVM with Hyperparameter Tuning

```
param_grid = {
    'C': [0.1, 1, 10],
    'kernel': ['linear', 'rbf'],
    'gamma': ['scale', 'auto']
}

grid = GridSearchCV(SVC(), param_grid, refit=True, cv=5, scoring='accuracy')
grid.fit(X_train, y_train)

print("Best Parameters:", grid.best_params_)
print("Validation Accuracy:", grid.score(X_val, y_val))
```

```
Best Parameters: {'C': 10, 'gamma': 'auto', 'kernel': 'rbf'}
Validation Accuracy: 0.8
```

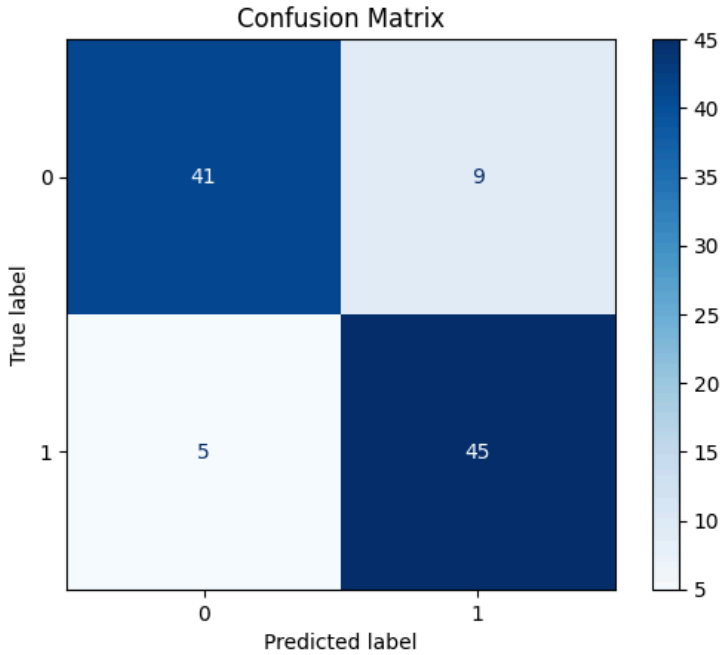
In this step, we are training an SVM (Support Vector Machine) model to classify the data.
We use GridSearchCV to test different combinations of parameters like C, kernel, and gamma.
It finds the best combination that gives the highest accuracy through cross-validation.
This helps us choose the most effective settings for the SVM model automatically.

NAME: Bhushan Malpani DIV: D15C ROLL NO: 33

Step 6: Evaluate on Test Data

```python
# Best model from GridSearchCV
best_model = grid.best_estimator_
y_pred = best_model.predict(X_test)

# Accuracy
print("Test Accuracy:", accuracy_score(y_test, y_pred))

# Classification report
print("\nClassification Report:\n", classification_report(y_test, y_pred))

# Confusion matrix
cm = confusion_matrix(y_test, y_pred)
disp = ConfusionMatrixDisplay(confusion_matrix=cm)
disp.plot(cmap=plt.cm.Blues)
plt.title("Confusion Matrix")
plt.show()
```

```
Test Accuracy: 0.86

Classification Report:
              precision    recall  f1-score   support

           0       0.89      0.82      0.85        50
           1       0.83      0.90      0.87        50

    accuracy                           0.86       100
   macro avg       0.86      0.86      0.86       100
weighted avg       0.86      0.86      0.86       100
```



NAME: Bhushan Malpani DIV: D15C ROLL NO: 33

Q.5 Train Regression Model and visualize the prediction performance of trained model

Dataset Description:

This dataset is focused on heart disease prediction, where several features (patient demographics, clinical measures, and medical history) are used to predict various health indicators related to the heart. Let's break down the columns:

1. Unnamed: 0:
    - A non-essential index column (likely used for row identification).
2. Age:
    - The age of the patient (numeric).
    - Age plays a significant role in the risk of heart disease.
3. Sex:
    - Gender of the patient (binary: 0 for female, 1 for male).
4. ChestPain:
    - Type of chest pain experienced by the patient (categorical).
    - Values like "typical", "asymptomatic", "nonanginal", and "nontypical" are used to classify the type of chest pain, which can be a symptom of heart disease.
5. RestBP (Resting Blood Pressure):
    - Resting blood pressure (mm Hg).
    - Blood pressure is a key indicator of heart disease risk.
6. Chol (Cholesterol):
    - Serum cholesterol level in mg/dl.
    - High cholesterol is often associated with heart disease.
7. Fbs (Fasting Blood Sugar):
    - Fasting blood sugar (binary: 0 if < 120 mg/dl, 1 if ≥ 120 mg/dl).
    - High fasting blood sugar may indicate a higher risk of heart disease.
8. RestECG (Resting Electrocardiographic Results):
    - Results of the resting electrocardiogram (categorical).
    - Possible values could indicate normal, ST-T wave abnormality, or left ventricular hypertrophy.
9. MaxHR (Maximum Heart Rate):
    - Maximum heart rate achieved during exercise (numeric).
    - A lower maximum heart rate can indicate poor cardiovascular fitness.
10. ExAng (Exercise Induced Angina):
    - Whether or not exercise induced angina (chest pain) occurred (binary: 0 or 1).
    - Induces a measure of the patient's ability to exercise without chest pain.
11. Oldpeak:
    - Depression of the ST segment in the electrocardiogram during exercise (numeric).
    - It's used to evaluate heart ischemia, which indicates potential coronary artery disease.

12. Slope:
    - The slope of the peak exercise ST segment (categorical).
    - This is related to the degree of heart disease, showing if the heart rate response is abnormal during exercise.
13. Ca (Number of Major Vessels Colored by Fluoroscopy):
    - The number of major blood vessels (0 to 3) that have been colored by fluoroscopy during an angiogram (numeric).
    - Used as a measure of coronary artery disease severity.
14. Thal:
    - A blood disorder associated with the heart (categorical).
    - Values like "fixed", "normal", or "reversible" could indicate various stages of the heart disease or the condition of the coronary arteries.
15. AHD (Heart Disease):
    - Whether the patient has heart disease (binary: "Yes" or "No").
    - The target variable for classification, indicating if the patient has a heart condition.

Step 1: Import necessary libraries

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns

from sklearn.model_selection import train_test_split, GridSearchCV
from sklearn.linear_model import Ridge, LinearRegression
from sklearn.preprocessing import OneHotEncoder, StandardScaler
from sklearn.compose import ColumnTransformer
from sklearn.pipeline import Pipeline
from sklearn.metrics import r2_score, mean_absolute_error, mean_squared_error
```

Step 2: Load the dataset

```
[17] import pandas as pd

    # Load dataset
    df = pd.read_csv("/content/Heart.csv")

    # Drop index column if present
    df.drop(columns=['Unnamed: 0'], errors='ignore', inplace=True)

    # Convert categorical to numerical for correlation analysis
    df_encoded = pd.get_dummies(df, drop_first=True)

    # Display head
    df_encoded.head()
```

	Age	Sex	RestBP	Chol	Fbs	RestECG	MaxHR	ExAng	Oldpeak	Slope	Ca	ChestPain_nonanginal	ChestPain_nontypical	ChestPain_typical	Thal_normal	Thal_reversable	AHD_Yes
0	63	1	145	233	1	2	150	0	2.3	3	0.0	False	False	True	False	False	False
1	67	1	160	286	0	2	108	1	1.5	2	3.0	False	False	False	True	False	True
2	67	1	120	229	0	2	129	1	2.6	2	2.0	False	False	False	False	True	True
3	37	1	130	250	0	0	187	0	3.5	3	0.0	True	False	False	True	False	False
4	41	0	130	204	0	2	172	0	1.4	1	0.0	False	True	False	True	False	False

NAME: Bhushan Malpani DIV: D15C ROLL NO: 33

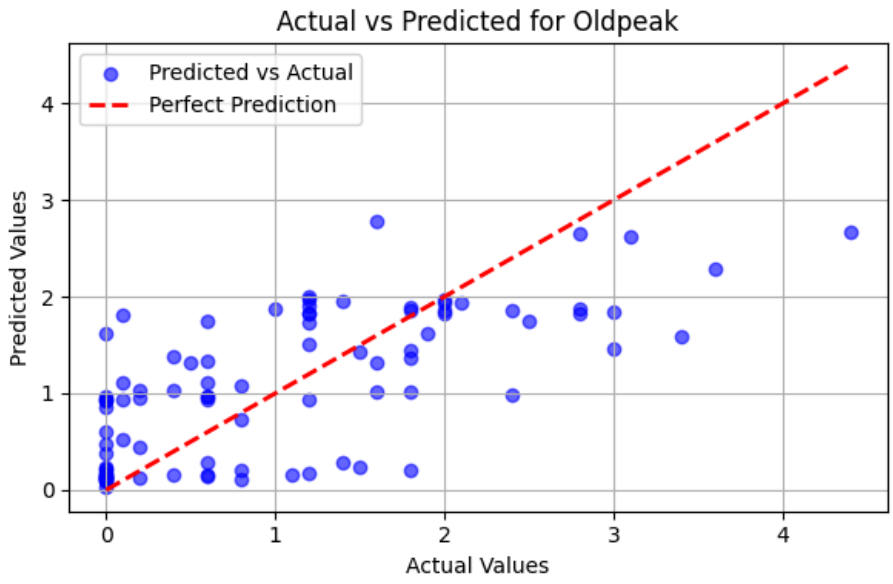
Step 3: Define the Linear Regression Model using OOP

```
# Model definition from previous step
class LinearModelForTarget:
    def __init__(self, target, top_features):
        self.target = target
        self.features = top_features
        self.model = LinearRegression()

    def train_and_evaluate(self, data):
        X = data[self.features]
        y = data[self.target]

        X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3, random_state=42)

        self.model.fit(X_train, y_train)
        y_pred = self.model.predict(X_test)

        r2 = r2_score(y_test, y_pred)
        n, p = X_test.shape
        adj_r2 = 1 - (1 - r2) * (n - 1)/(n - p - 1)
        mae = mean_absolute_error(y_test, y_pred)
        rmse = np.sqrt(mean_squared_error(y_test, y_pred))

        print(f"\nMetrics for {self.target}:")
        print(f"R2 Score: {r2:.4f}")
        print(f"Adjusted R2: {adj_r2:.4f}")
        print(f"MAE: {mae:.4f}")
        print(f"RMSE: {rmse:.4f}")
```

Step 4: Train the model and evaluate the model then plot the predictions:

```
feature_sets = {
    'Oldpeak': ['Slope', 'AHD_Yes', 'MaxHR', 'Thal_normal']
}

import matplotlib.pyplot as plt
import numpy as np

# Step 8: Train and evaluate each target using its best feature set and plot the predictions
for target, features in feature_sets.items():
    print(f"\n📊 Training model for {target} with features: {features}")
    model = LinearModelForTarget(target, features)
    model.train_and_evaluate(df_encoded)

    # Predictions for plotting
    X = df_encoded[features]
    y = df_encoded[target]
    X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3, random_state=42)
    y_pred = model.model.predict(X_test)

    # Plot Actual vs Predicted
    plt.figure(figsize=(6, 4))
    plt.scatter(y_test, y_pred, color='blue', alpha=0.6, label='Predicted vs Actual')
    plt.plot([min(y_test), max(y_test)], [min(y_test), max(y_test)], 'r--', lw=2, label='Perfect Prediction')
    plt.xlabel("Actual Values")
    plt.ylabel("Predicted Values")
    plt.title(f"Actual vs Predicted for {target}")
    plt.legend()
    plt.grid(True)
    plt.tight_layout()
    plt.show()
```

```
Training model for Oldpeak with features: ['Slope', 'AHD_Yes', 'MaxHR', 'Thal_normal']

Metrics for Oldpeak:
R2 Score: 0.4746
Adjusted R2: 0.4501
MAE: 0.5949
RMSE: 0.7489
```



Q.6 What are the key features of the wine quality data set? Discuss the importance of each feature in predicting the quality of wine? How did you handle missing data in the wine quality data set during the feature engineering process? Discuss the advantages and disadvantages of different imputation techniques.

Dataset: http://kaggle.com/datasets/yasserh/wine-quality-dataset

Key Features of the Wine Quality Dataset

1. Fixed Acidity
   - Represents non-volatile acids like tartaric acid.
   - Importance: Impacts wine's freshness and stability. Too much or too little affects taste.
2. Volatile Acidity
   - Mainly acetic acid (vinegar-like smell).
   - Importance: High levels lead to unpleasant aroma, reducing quality.
3. Citric Acid
   - Found naturally in wine, adds freshness and flavor.
   - Importance: Enhances flavor, contributes to acidity balance.
4. Residual Sugar
   - Sugar left after fermentation.

    - Importance: Affects sweetness; balance is key for quality perception.
5. Chlorides
    - Amount of salt in wine.
    - Importance: High levels negatively affect taste; small amounts may enhance flavor.
6. Free Sulfur Dioxide
    - Prevents microbial growth and oxidation.
    - Importance: Crucial for wine preservation but must be balanced.
7. Total Sulfur Dioxide
    - Includes both free and bound SO_2.
    - Importance: Excess leads to a pungent smell; impacts shelf life and safety.
8. Density
    - Related to sugar and alcohol content.
    - Importance: Indicates fermentation status and body of wine.
9. pH
    - Measures acidity or basicity.
    - Importance: Affects stability, color, and taste.
10. Sulphates
    - Antimicrobial and antioxidant.
    - Importance: Contributes to SO_2 levels; affects preservation and flavor.
11. Alcohol
    - Ethanol content in wine.
    - Importance: Strongly correlated with quality. Higher alcohol often perceived as higher quality.

Handling Missing Data During Feature Engineering

1. Detection:
    - Used df.isnull().sum() in Pandas to check missing values.
2. Imputation Techniques Used:
    - Numerical columns (e.g., alcohol, pH):
        - Used mean or median imputation depending on skewness.
        - For example:
          df['alcohol'].fillna(df['alcohol'].mean(), inplace=True)

1. Mean Imputation

Advantages:

- Simple and fast to implement.
- Maintains dataset size.
  Works well with symmetric, normally distributed data.

Disadvantages:

- Affected by outliers.
- Reduces data variability.
- Can introduce bias in skewed distributions.

2. Median Imputation

Advantages:

- Robust to outliers.
- Better suited for skewed data.
- Preserves central tendency better than mean for non-normal data.

Disadvantages:

- Still doesn't account for correlation between features.
- Less effective for normally distributed data.

3. Mode Imputation (for categorical or discrete data)

Advantages:

- Simple to apply.
- Maintains most frequent category.

Disadvantages:

- Not suitable for continuous data.
- Can cause overrepresentation of the mode.

4. Dropping Missing Rows

Advantages:

- Very simple to apply.
- Avoids introducing potential bias from imputation.

Disadvantages:

- Leads to data loss.
- Not suitable if many rows have missing values.
- May reduce model performance due to smaller training set.