NATIONAL UNIVERSITY
of Computer & Emerging Sciences

Applied Artificial Intelligence

Assignment 1

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Contents

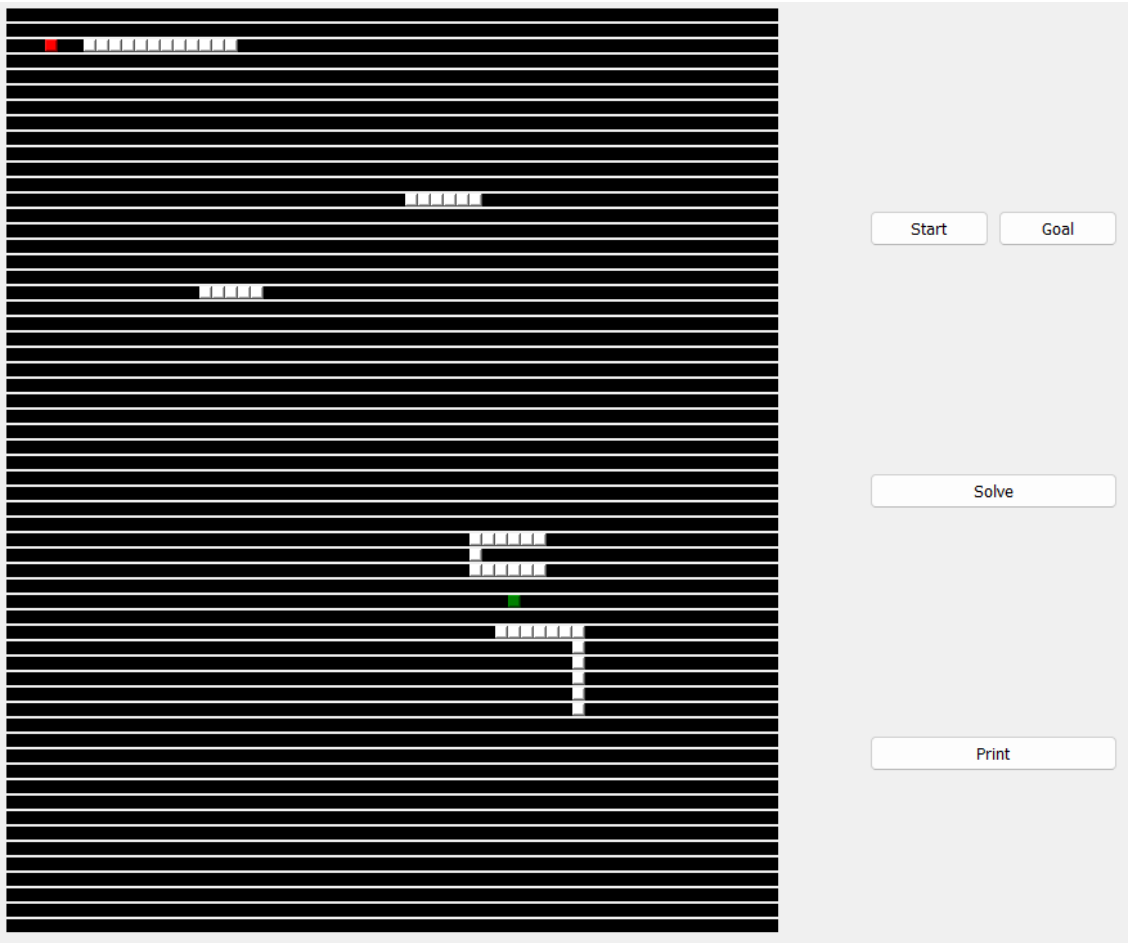
Question Number: 1

Q1. a. Implement Evolutionary Search for RESCUE 1122. You are required to design the complete system as (SIMULATION) for Route planning for optimal path to reach the accident site (Shortest-distance finding problem). You can use any tool for its implementation. You can use google maps as well. You can use bit-map method for simulation by using (40 x 40) and (60 x 60) grid and use cells as 2D locations e.g., start-state (2, 3) to destination (38, 39) with obstacles and roads infrastructure as well. First, map your problem and then propose solution. You can use case study of Rescue 1122 ambulance service in Lahore and design an optimized scheduling system. It will be a simulation and modeling project in programming. Compare the optimized route generated by GA with the route generated by A* search algorithm. (50 marks)

Answer:

Problem:

1)



2)

A 60 by 60 Grid is used to represent the state space and the is set at start-state (2, 3)

And the destination is set at (38, 39) with obstacles (White Blocks) and roads infrastructure (Black Blocks).

Solution:

Evolutionary Search is used to find the solution in the following steps:

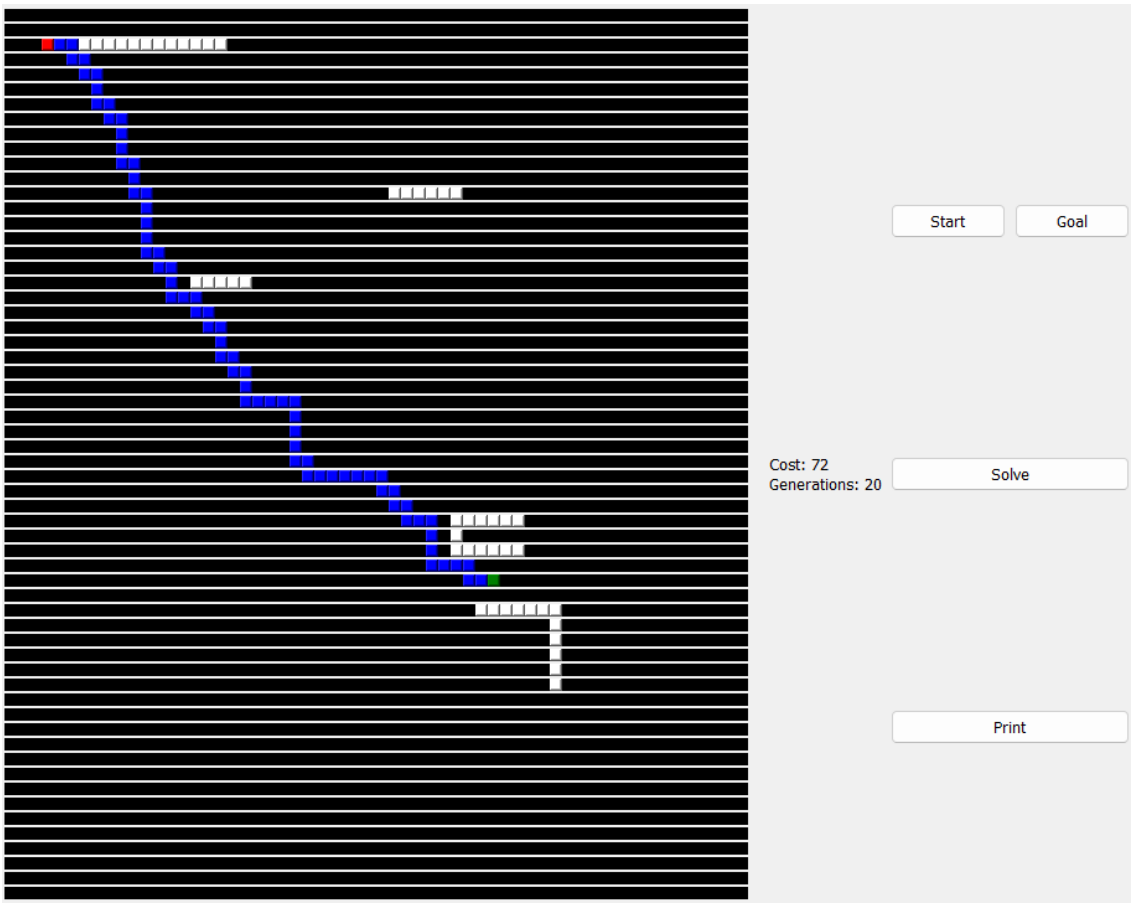
1. **Initializations**:
    - The algorithm initializes an empty population list to store paths.
    - It sets the generation counter to 0 and initializes an empty list **avg_fitness_values** to store average fitness values over generations.
2. **Population Initialization**:
    - The algorithm generates random paths until the population size reaches 30.
    - It calls the **random path ()** function to generate random paths.
    - Each generated path is appended to the population list.

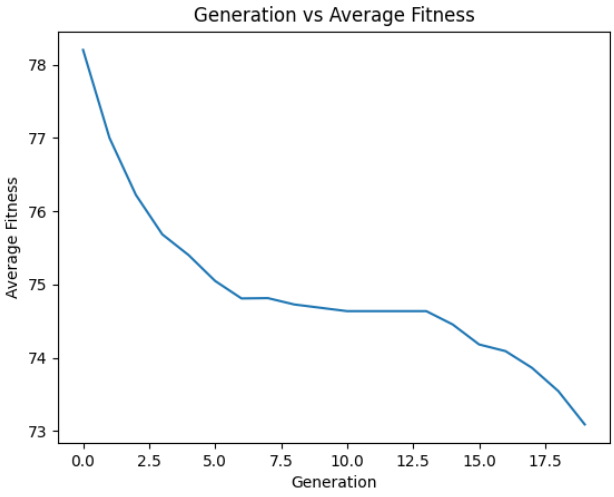
3. **Evolution Loop**:
    - The algorithm enters a loop that runs for a maximum of 1000 iterations.
    - It increments the generation counter and prints the current iteration and population.
    - Fitness of each path in the population is evaluated using the **fitness ()** function.
    - The best path with the minimum fitness score is identified.
    - The algorithm checks for stability in fitness. If the current best fitness score is not improving for 20 consecutive iterations, the loop terminates.
    - Average fitness value is calculated and appended to **avg_fitness_values**.
    - Selection: The algorithm selects 10 paths from the population based on their fitness scores using random weighted selection.
    - Crossover: It performs crossover between selected paths to generate offspring paths using the **crossover ()** function.
    - Mutation: It mutates some paths from the selected paths using the **mutate_path ()** function.
    - The offspring and mutated paths are added to the population.
    - Paths with low fitness scores are removed by selecting the top 80% of paths based on fitness scores.
    - The loop continues until stability in fitness is achieved or the maximum number of iterations is reached.
4. **Mutation** (**mutate path ()** function):
    - This function mutates a given path by randomly changing a gene (grid cell).
    - It selects a random index in the path and finds valid adjacent neighbors to the current gene.
    - If valid neighbors are found, it selects one of them randomly and replaces the current gene with the new gene, ensuring that the path remains continuous.
5. **Fitness Evaluation** (**fitness ()** function):
    - This function evaluates the fitness of a path based on its length and distance to the goal.
    - It calculates the length of the path and subtracts the Manhattan distance between the last point of the path and the goal.
    - The fitness score represents the desirability of the path; lower scores indicate better paths.
6. **Crossover** (**crossover ()** function):
    - This function performs a crossover between two paths.
    - It selects a common point (gene) from both paths and combines the segments before and after that point to create a new path.
    - This ensures that the integrity of paths is maintained, and the resulting path is a valid solution.

7. **Random Path Generation** (**random path ()** function):
    - This function generates a random path from the start point to the goal point using a heuristic-based approach.
    - The algorithm selects random possible moves based on heuristic values (Manhattan distance to the goal) and the length of the path.
8. **Plotting**:
    - After the evolution loop terminates, the algorithm plots a graph showing the average fitness values over generations.
9. **Return**:
    - The best path found, and the total number of generations (steps) taken are returned as the output of the algorithm.

Solution with Evolutionary:

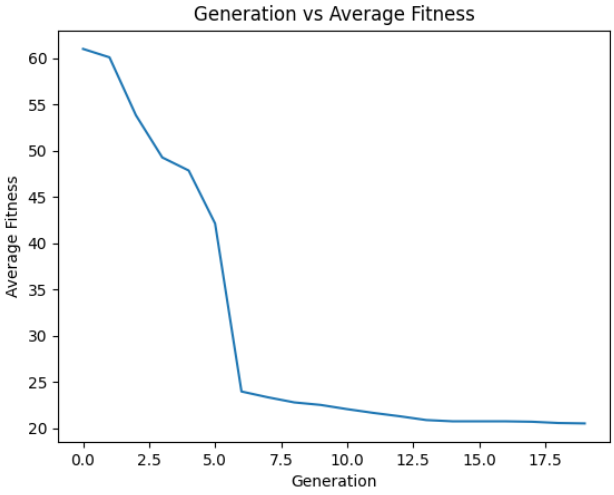
1)





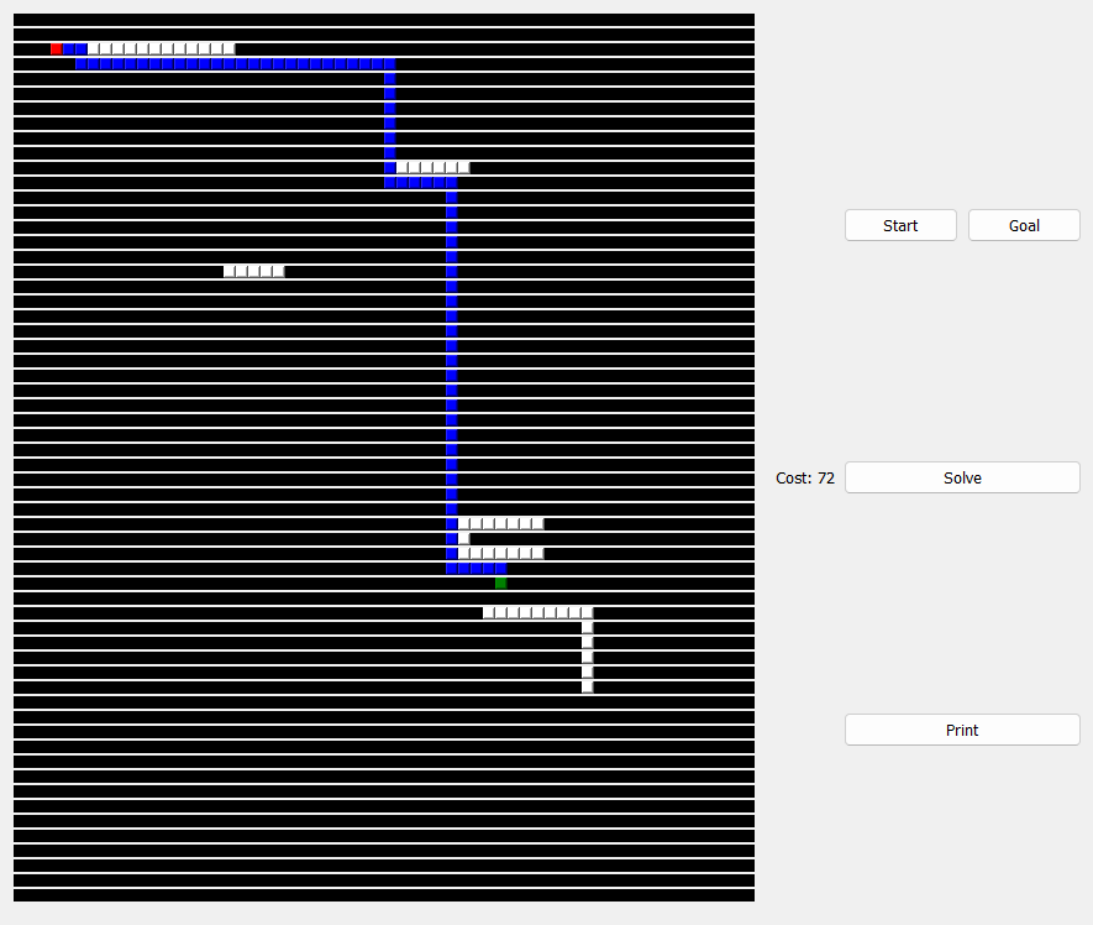
2)


Start
Goal
Cost: 18
Generations: 20
Solve
Print

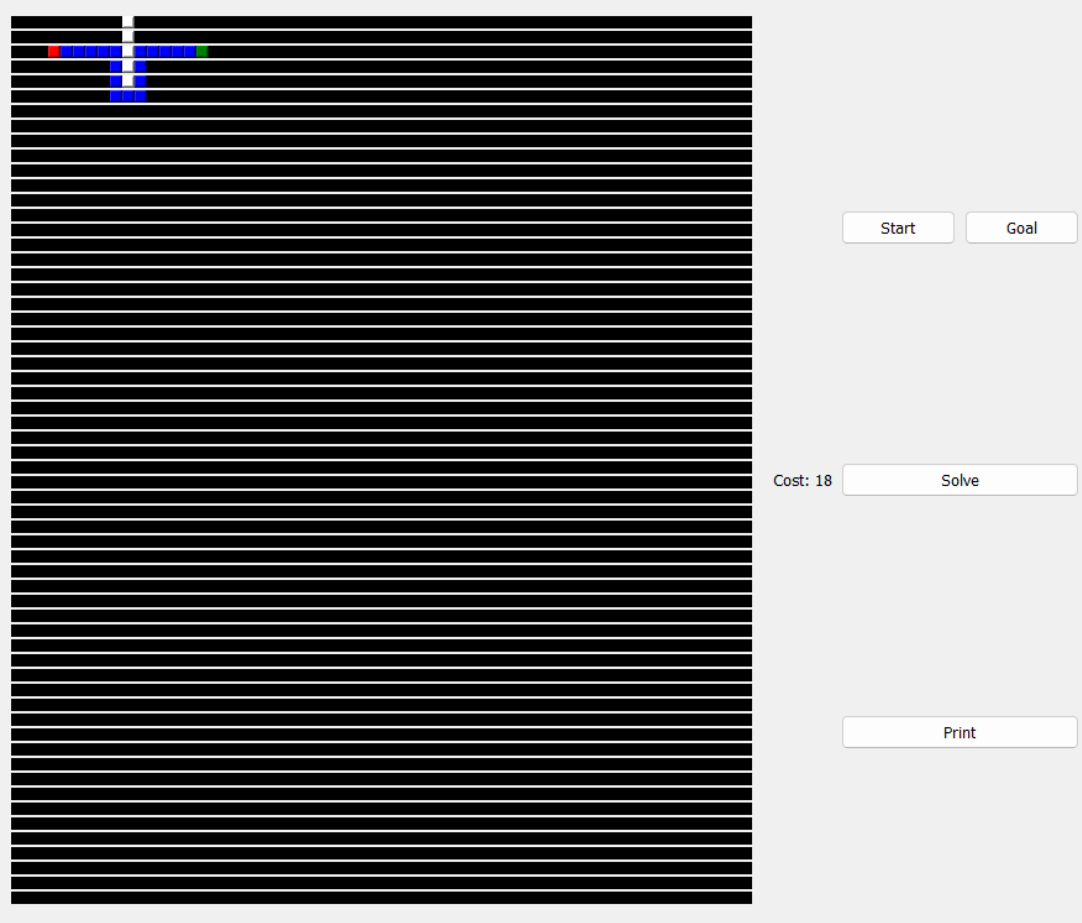

Generation vs Average Fitness
Average Fitness
Generation
60
55
50
45
40
35
30
25
20
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5

Solution with A* Search:

1)



2)



A* vs Evolutionary Search:

1. **Approach**:
    - **A***: A* search is a classic informed search algorithm that uses a heuristic to efficiently search for the shortest path from a start node to a goal node in a graph or grid.
    - **Evolutionary Search**: The evolutionary search algorithm is a population-based metaheuristic optimization technique inspired by the process of natural selection. It iteratively evolves a population of candidate solutions towards an optimal solution.
2. **Heuristics**:
    - **A***: A* requires a consistent heuristic function that provides an estimate of the cost from a given node to the goal node. It uses this heuristic to guide the search towards the goal efficiently.
    - **Evolutionary Search**: The evolutionary search algorithm does not require a specific heuristic function. Instead, it evaluates the fitness of candidate solutions based on predefined criteria. In the provided code, the fitness function considers the length of the path and its distance to the goal.
3. **Search Space Exploration**:

- **A***: A* explores the search space systematically, expanding nodes with lower estimated costs first. It maintains a priority queue (open list) to efficiently select the next node for expansion.
- **Evolutionary Search**: The evolutionary search algorithm explores the search space through the evolution of a population of candidate solutions. It employs mechanisms such as selection, crossover, and mutation to explore and exploit the search space.

4. **Optimization Objective**:
   - **A***: A* aims to find the optimal solution with the minimum path cost from the start node to the goal node. It guarantees optimality under certain conditions, such as consistent heuristic functions and finite search spaces.
   - **Evolutionary Search**: The evolutionary search algorithm does not guarantee optimality. It aims to find a satisfactory solution that meets predefined criteria, such as the length of the path and the proximity to the goal. The quality of the solution depends on factors such as population size, evolutionary operators, and termination conditions.
5. **Performance**:
   - **A***: A* is generally more efficient for finding optimal solutions in well-defined search spaces with known heuristic information. It can handle relatively small to medium-sized problems effectively.
   - **Evolutionary Search**: The evolutionary search algorithm is more suitable for complex optimization problems with large or dynamic search spaces where heuristic information may be unavailable or insufficient. It may require more computational resources and iterations to converge to a satisfactory solution.
6. **Convergence**:
   - **A***: A* converges to the optimal solution when the search space is finite, and the heuristic function is admissible and consistent.
   - **Evolutionary Search**: The evolutionary search algorithm converges to a satisfactory solution based on the termination criteria as used in the above algo the maximum number of iterations or stability in fitness values. Convergence behavior depends on various factors, including the population size, evolutionary operators, and problem complexity.

7. Solution:

The solutions derived from both algorithms exhibit an appearance of optimality. However, it is essential to note that this optimality is not consistently applicable across all problem scenarios. Specifically, the optimality of the solution produced by the Genetic Algorithm is heavily reliant on the quality and composition of the initial population generated by the algorithm itself. It is worth emphasizing that this initial population is formulated entirely based on random selection, introducing variability and potential unpredictability in the optimization process. Therefore, while the Genetic Algorithm may yield optimal solutions under certain conditions, its performance and optimality can be significantly influenced by the stochastic nature of its initial population generation. Furthermore, Algorithm A consistently returns the optimal path.

Question Number: 2

Q2. Comparative analysis of features/functions of 4-5 commercial tools/applications for route planning available in different parts of the world e.g., USA, UK, Europe, UAE, etc. For example: www.mapquest.com and WAZE https://www.waze.com/livemap https://developers.google.com/waze/, THEAA, RAC, TomTom, Green Flag, etc. Propose some modifications or innovation in these route planners for Pakistani environment. Can we incorporate some extra services like blood donation, ride sharing, security, smart and secure tourism, restaurant recommendation system within main car navigation system, etc. What are the requirements for such systems from the AI perspective? (30 marks)

Answer:

a)

Applications for Route planning	**TomTom Maps**	**Waze**	**Route4Me**	**Gaode Map**	**THEAA**
Geographic Coverage	TomTom Maps offers extensive geographic coverage globally, providing mapping data and navigation services in over 150 countries.	Waze covers many countries worldwide, with a strong presence in North America, Europe, and parts of Asia, but may have limited coverage in some regions.	Route4Me primarily focuses on North America but offers limited coverage in other parts of the world.	Gaode Map is a leading mapping and navigation service provider in China, offering comprehensive coverage and detailed maps of Chinese cities and regions.	THEAA (The Automobile Association) primarily focuses on the UK and provides mapping, navigation, and route planning services tailored to the British road network.
Navigation	TomTom Maps offers advanced routing algorithms, real-time traffic updates, alternative routes, and turn-by-turn navigation instructions.	Waze provides dynamic routing based on real-time traffic conditions, crowd-sourced incident reports, and user feedback, helping users avoid traffic congestion and delays.	Route4Me specializes in multi-stop route optimization for delivery fleets and field service teams, allowing users to plan efficient routes with multiple stops and optimize them for time and distance.	Gaode Map offers navigation and route planning services tailored to the Chinese road network, with features like real-time traffic updates, congestion alerts, and voice-guided navigation.	THEAA provides route planning and navigation services specific to the UK, offering features such as traffic updates, road closures, and points of interest along the route.

Traffic and Incident Reporting	TomTom Maps provides real-time traffic information, incident reports, and congestion alerts to help users navigate efficiently.	Waze relies on crowd-sourced data for reporting traffic incidents, accidents, police checkpoints, and other hazards in real-time.	Route4Me offers limited traffic reporting capabilities compared to dedicated navigation apps like TomTom and Waze, focusing more on route optimization for businesses.	Gaode Map provides real-time traffic updates, congestion alerts, and incident reports tailored to the Chinese road network, leveraging crowd-sourced data and government sources.	THEAA offers traffic information, congestion updates, and incident reports specific to the UK road network, helping users plan routes and avoid delays.
Offline Navigation	TomTom Maps offers offline navigation capabilities, allowing users to download maps and use them without an internet connection, which is useful for navigating in areas with poor network coverage.	Waze primarily relies on online connectivity for real-time updates and crowd-sourced data, and its offline capabilities are limited to pre-downloading routes for navigation without real-time traffic information.	Route4Me focuses more on online route optimization and navigation for businesses, and its offline capabilities may be limited compared to dedicated navigation apps like TomTom and Waze.	Gaode Map provides offline navigation features tailored to the Chinese market, allowing users to download maps for offline use and navigate without an internet connection.	THEAA offers limited offline navigation capabilities compared to dedicated navigation apps, and users may need internet connectivity for real-time traffic updates and routing information.
Integration with Public Transit	Provides integration with public transit systems in select cities, offering route planning and navigation options that include public transportation, such as buses, trains, and subways.	Offers limited integration with public transit systems, primarily focusing on driving directions and route optimization for private vehicles, ridesharing, and carpooling.	Does not provide integration with public transit systems, as its primary focus is on route optimization and planning for commercial fleets and field service teams.	Offers comprehensive integration with public transit systems in China, providing route planning, schedules, and real-time updates for buses, subways, and other modes of public transportation.	Does not offer integration with public transit systems, as its services are tailored to drivers and motorists navigating UK road networks.
User Community	TomTom Maps offers limited social features	Waze encourages user participation	Route4Me is designed for businesses and lacks social features aimed at	Gaode Map integrates social features such as	THEAA does not offer extensive

	compared to apps like Waze, focusing more on navigation and routing functionality.	through social features such as reporting incidents, sharing real-time traffic information, and interacting with other users on the platform.	individual users, focusing instead on optimizing routes for delivery fleets and field service teams.	location sharing, check-ins, and group navigation, catering to the preferences of Chinese users.	social features but focuses on providing navigation and route planning services tailored to the needs of UK Vehicles.

b)

Propose some modifications or innovation in these route planners for Pakistani environment:

Localization and Support for the Urdu Language:
Provide Urdu language support and localization capabilities in route planners for Pakistani users who might like to navigate in their own tongue.
To make navigation more accessible and easier to use for people who are more fluent in Urdu, provide voice-guided navigation directions in the language.

Integration with Local Transportation Modes:
Incorporate local transportation modes including Qingqis, rickshaws, and local buses to provide users in Pakistani cities extensive multi-modal route planning choices.
Incorporate up-to-date information and timetables for public transport services to help consumers plan their trips more effectively.

Handling Road Hazards and Conditions:
Add functions to route planners that consider Pakistani road conditions and risks that are frequently encountered, such potholes, road closures, construction zones, and unpredictable traffic patterns.
Help users avoid traffic jams, barricades, and other obstructions on Pakistani roadways by offering real-time notifications and ideas for an alternate route.

Features for Safety and Security:
Include safety and security elements in route planners to handle issues like access to emergency services, security checkpoints, and locations that are prone to crime.
Users should get real-time safety warnings and messages that include details on nearby law enforcement actions, traffic accidents, and other security threats.

Alternative Routes for Bicycles and Motorbikes:
Include bike and motorcycle-specific routing choices that account for things like small streets, gridlock, and roads that are appropriate for these types of transportation.
Provide riders on motorcycles and bicycles with specific navigational instructions and safety advice, such as bike lanes and routes designed with two wheels in mind.

c)

Yes, we incorporate some extra services like blood donation, ride sharing, security, smart and secure tourism, restaurant recommendation system within the main car navigation system, etc.

Personalization and Context Awareness:
Context awareness and personalization are crucial for providing services and suggestions that are specifically catered to the needs and preferences of each user. This entails using AI-driven personalization algorithms that use user profiles, past data, and contextual information to provide suggestions and experiences that are tailored to each user's interests and situation. The system can improve user happiness and engagement by meeting individual requirements and preferences with timely suggestions that are relevant and personalized through the integration of context awareness and personalization features.

Feedback and Learning Mechanisms:
The automobile navigation system's suggestions and services must be continually improved in terms of quality and relevancy, which is why feedback and learning mechanisms are so important. To do this, feedback mechanisms must be included to gather user comments, evaluations, and ratings. Recommendation models and algorithms will then be improved over time with the use of this data. In terms of artificial intelligence, it entails creating AI-driven algorithms for feedback analysis to assess user input, spot trends, and modify recommendation models in response to user preferences and satisfaction levels. Through the incorporation of feedback and learning processes, the system may enhance user happiness and loyalty by continuously improving its capabilities and better meeting the requirements and expectations of users.

Real-time Data Processing:
Providing current information on a range of services, such as transportation availability, security warnings, neighboring attractions, and restaurant openings and closings, requires real-time data processing. From an artificial intelligence (AI) standpoint, this means putting streaming data processing strategies and real-time analytics algorithms into practice to manage constant data streams, identify trends, and provide consumers with timely updates and notifications. The system can guarantee that customers obtain pertinent and precise information promptly by enabling real-time data processing, which will improve their overall experience and pleasure.

Geospatial Analysis:
Finding local service providers, attractions, and areas of interest that are pertinent to consumers' requirements and interests requires the application of geographic analysis. From an AI standpoint, this entails processing location-based data, calculating distances, figuring out routes, and producing spatially aware suggestions depending on the user's present position and destination by using geospatial algorithms and methodologies. The system's integration of geospatial analytic capabilities can yield significant insights and suggestions to users, according to their geographical location. This can ultimately improve the relevance and usability of the services provided.

Machine Learning Models:
Using machine learning models is a crucial prerequisite for adding new services to a vehicle navigation system. To provide personalized suggestions and services, these models are essential for evaluating past data, user preferences, and contextual information. In terms of artificial intelligence, it entails creating and honing machine learning models for applications including sentiment analysis, recommendation engines, anomaly detection, and predictive analysis. With the help of these models, the system is better equipped to comprehend user behavior, anticipate preferences, and provide pertinent recommendations, all of which improve user happiness and overall experience.

Question Number: 3

Q3. Comparative analysis of open source as well as commercial AI tools [artificial intelligence tools, data mining tools, machine learning tools, statistical analysis tools etc.,]. Can we use ChatGPT and/or BARD in/for Artificial Intelligence applications? Provide details of three such applications. (20 marks)

Answer:

a)

AI Tool	**TensorFlow** 	**Databricks** 
Category	Machine Learning	Machine Learning
Purpose	TensorFlow is an open-source deep learning framework created by the Google Brain team that is mostly used for creating and refining machine learning models, particularly neural networks. It provides a thorough environment for creating, implementing, and overseeing machine learning applications.	A unified analytics platform for big data processing and machine learning. Data scientists, data engineers, and machine learning engineers may collaborate on data analytics, data engineering, and machine learning activities in this collaborative environment.
Cost	TensorFlow is open-source and free to use, with no licensing costs. However, deploying and managing TensorFlow models in production may incur costs for infrastructure and cloud services.	Databricks offers both free and paid plans, with pricing based on usage and features. The paid plans provide additional features such as advanced security, job scheduling, and premium support.
Data Visualization	TensorFlow does not provide built-in tools for data visualization and exploration. Users often rely on external libraries like Matplotlib or Seaborn for visualizing data and model results.	Databricks provides built-in support for data visualization and exploration through its notebook interface. Users can create interactive visualizations using libraries like matplotlib, ggplot, and Databricks-native visualization libraries.
Supported Programming Languages	TensorFlow primarily supports Python for model development and training, with official APIs for other languages like C++ and Java. However, most of the ecosystem and community support is centered around Python.	Databricks supports multiple programming languages, including Python, Scala, R, and SQL. Users can leverage their preferred language for data analysis, machine learning, and data engineering tasks within the Databricks environment.
Model Deployment	TensorFlow provides tools and libraries for deploying trained models in production environments.	Databricks supports model deployment and serving through various methods, including deploying

	TensorFlow Serving, for example, enables serving TensorFlow models over RESTful APIs, making it easy to integrate with web applications and microservices.	models as Apache Spark MLlib pipelines, using Databricks MLflow for model lifecycle management, and integrating with Azure Machine Learning for deploying models to Azure services.
Scalability	TensorFlow is designed to scale from single devices to distributed computing clusters. It supports distributed training across multiple GPUs and TPUs, as well as deployment on cloud platforms like Google Cloud Platform (GCP) and Amazon Web Services (AWS).	Databricks is built on top of Apache Spark, which is known for its scalability and ability to handle large-scale data processing. Databricks provides built-in support for distributed computing, enabling users to scale their data analytics and machine learning workflows as needed.

AI Tool	**PyTorch** 	**Amazon SageMaker** 
Category	Deep Learning	Deep Learning
Purpose	PyTorch is an open-source deep learning framework primarily developed by Facebook's AI Research lab (FAIR). It is known for its dynamic computation graph, which enables flexible model design and debugging. PyTorch focuses on research prototyping, experimentation, and building custom deep learning models.	Amazon SageMaker is a fully managed service provided by Amazon Web Services (AWS) for building, training, and deploying machine learning models at scale. It offers a comprehensive platform for end-to-end machine learning workflows, including data preprocessing, model training, hyperparameter tuning, and model hosting.
Scalability	PyTorch supports distributed training across multiple GPUs and machines, enabling scalability for large-scale model training. However, users need to manage distributed computing infrastructure and configuration manually.	Amazon SageMaker is designed for scalability and can handle large-scale model training and deployment seamlessly. It automatically provisions and scales computing resources based on workload demands, making it suitable for training complex models on massive datasets.
Model Deployment	PyTorch does not provide built-in tools for model deployment and serving. Users typically deploy PyTorch models using frameworks like Flask or FastAPI and host them	Amazon SageMaker provides built-in support for deploying trained models in production environments. It offers managed hosting and automatic scaling of model endpoints, enabling

	on cloud platforms or dedicated servers.	real-time inference with low latency and high availability.
Model Training	PyTorch provides flexibility in model training and experimentation, allowing users to define and customize models with ease. It offers dynamic computation graphs, which are particularly useful for building complex architectures and experimenting with different model designs and hyperparameters.	Amazon SageMaker provides tools for automating model training and hyperparameter tuning, allowing users to efficiently search for optimal model configurations. It offers built-in algorithms and frameworks for common machine learning tasks, making it easy to get started with model training.
Customization	PyTorch is highly customizable and extensible, allowing users to easily implement custom layers, loss functions, and optimization algorithms. It provides a rich ecosystem of libraries and extensions for building specialized models and applications.	While Amazon SageMaker offers flexibility in model training and deployment, it may have limitations in terms of customization compared to PyTorch. Users may need to work within the constraints of the SageMaker environment and APIs when implementing custom functionality.

AI Tool	**Apache Spark**	**KNIME**
Category	Data Mining	Data Mining
Purpose	Apache Spark is an open-source distributed computing framework designed for big data processing and analytics. It provides in-memory processing capabilities and supports various data processing tasks, including batch processing, stream processing, machine learning, and graph processing.	KNIME (Konstanz Information Miner) is an open-source data analytics platform that enables users to visually design, execute, and analyze data workflows. It offers a wide range of tools and extensions for data preprocessing, modeling, visualization, and reporting, making it suitable for data science and analytics tasks.
Scalability	Apache Spark is designed for scalability and can handle large-scale data processing tasks across distributed computing clusters. It provides built-in support for parallel processing and fault tolerance, enabling efficient processing of massive datasets.	KNIME's scalability depends on the underlying computing resources and infrastructure. While it supports parallel execution of workflows and can leverage distributed computing resources, it may not scale as seamlessly as Apache Spark for extremely large datasets or compute-intensive tasks.
Data Processing Capabilities	Apache Spark offers a wide range of data processing capabilities, including batch processing, stream processing, SQL queries, machine learning, and	KNIME provides tools and extensions for data preprocessing, transformation, filtering, aggregation, and analysis. It offers a

	graph processing. It provides libraries like Spark SQL, Spark Streaming, MLlib, and GraphX for different types of data processing tasks.	comprehensive set of nodes for working with various data types and formats, making it suitable for a diverse range of data processing tasks.
Cost	Apache Spark is open-source and free to use, with no licensing costs. However, users may incur costs for infrastructure, computing resources, and cloud services when deploying and running Spark applications.	KNIME Analytics Platform is open-source and free to use, but KNIME also offers commercial products and services, including KNIME Server and KNIME Extensions, which may require licensing fees based on usage and features.

b)

Yes, ChatGPT and BARD can be utilized in various artificial intelligence applications. Here are 3 such applications:

1) **Customer Support Chatbots**
   Customer Support ChatGPT and/or BARD-powered chatbots use cutting-edge natural language processing to comprehend and provide precise, timely responses to client requests. They provide individualized help, automate repetitive operations, effortlessly transfer control to human agents when necessary, and continually learn from encounters to gradually enhance the quality of their services. They are accessible 24/7. This scalable and affordable solution improves customer satisfaction and expedites support procedures for companies using a variety of media.

2) **Content Creation**
   ChatGPT and/or BARD can be utilized for content creation, generating diverse forms of creative content such as articles, stories, product descriptions, and more. Leveraging its natural language generation capabilities, ChatGPT and/or BARD can produce engaging and contextually relevant content tailored to specific requirements or prompts provided by users. This enables businesses, marketers, and content creators to streamline content generation processes, enhance productivity, and maintain a consistent flow of high-quality content across various platforms and channels.

3) **E-commerce Recommendation Systems**
   In e-commerce recommendation systems, ChatGPT and/or BARD contributes significantly by providing personalized product recommendations to users based on their browsing history, purchase behavior, and preferences. By analyzing user interactions and historical data, ChatGPT and/or BARD can generate tailored recommendations that are relevant and appealing to individual users, thereby improving the overall shopping experience, and increasing the likelihood of conversion. Additionally, ChatGPT and/or BARD can assist in generating dynamic content such as personalized product descriptions and promotional messages to further enhance engagement and drive sales. This application of ChatGPT enables e-commerce platforms to boost customer satisfaction, retention, and revenue by delivering targeted recommendations that meet the unique needs and interests of each user.