ARTIFICIAL INTELLIGENCE

ASSIGNMENT 2

INSTRUCTIONS **DUE DATE : 16 MARCH 2025 (12:00 AM)**

1. Assignments are to be done individually. You must complete this assignment by yourself. You cannot work with anyone else in the class or with someone outside of the class.
2. You have to use python programming language.
3. Plagiarism of any kind (copying from others and copying from the internet, etc.,) is not allowed and can result in zero marks in whole assignment category.
4. Your code must be properly commented.
5. Any assignment marked late by google will be considered late.
6. No marks will be assigned if any of the following deliverables are missing. The source code of the program. A pdf or word report containing a brief explanation of the steps involved in the program (each question) and the results obtained.
7. Put both source code and report in one folder, ZIP it and submit it. Your folder must be named as **ROLLNO_NAME.ZIP**

QUESTION 1

Consider an undirected graph G=(V,E), where:

- V is the set of vertices
- E is the set of edges

Your task is to assign colors to each vertex such that:

1. No two adjacent vertices share the same color (Standard Graph Coloring Constraint).
2. Minimize the number of colors used (Chromatic Number Constraint).

Additional Constraints

In addition to the basic graph coloring rules, you must also satisfy the following:

1. Degree-Based Coloring:
    - Higher-degree vertices should be assigned colors before lower-degree vertices.
2. Pre-Assigned Colors:
    - Some vertices may have predefined colors that cannot be changed.
3. Balanced Color Usage:
    - The number of vertices assigned to each color should be approximately balanced.
4. Distance Constraint:
    - Certain vertices must be assigned different colors even if they are not directly connected by an edge.
    - This extends the standard adjacency constraint to vertices that are two hops away.

<u>**Using Local Beam Search for Graph Coloring**</u>

1. Representation of States

- A state is a color assignment for all vertices.
- Each state is represented as an array of length $|V||V||V|$, where:
    - Each index corresponds to a vertex.
    - The value at that index represents the assigned color.

2. Initial State

- Start with a random valid coloring that satisfies the pre-assigned colors.

3. Successor Generation

- Generate new states by recoloring a vertex to a different color while ensuring that constraints are not violated.
- Preference should be given to modifying the colors of high-degree vertices first, to reduce conflicts efficiently.

4. Heuristic Function

To evaluate and select the best states, define a heuristic function based on additional constraints.

Graph Datasets for Testing

Also test your algorithm on the dataset attached as hypercube_dataset.txt (assuming that heuristics s in this dataset are given after applying additional constraint)

QUESTION 2 : Grocery Store Shelf Optimization Problem

Efficient product placement in a grocery store is a crucial challenge for retail managers to maximize space utilization and ensure quick access to high-demand products. The objective is to assign products to shelves while considering key constraints that enhance customer experience and operational efficiency.

Problem Statement

A grocery store receives various products daily and must allocate shelf space efficiently. Each product has unique storage requirements, and the store has limited shelf space. The goal is to create an optimized shelving plan that ensures effective space usage, easy product retrieval, and logical category placement.

Constraints:

1. **Shelf Capacity & Weight Limit**
   Each shelf has a maximum weight limit.
   Example: A shelf with a 50 kg capacity cannot store products exceeding this weight.
2. **High-Demand Product Accessibility**
   Frequently purchased products should be placed at eye level and near aisles to maximize sales and reduce customer search time.
   Example: Milk and bread should be placed at easily accessible shelves, whereas niche spices can be stored in higher or corner sections.
3. **Product Category Segmentation**
   Products should be grouped based on their categories for logical arrangement and ease of shopping.
   Example: Snacks should be placed in the same aisle, while dairy and frozen items should be located in refrigeration units.
4. **Perishable vs. Non-Perishable Separation**

Perishable goods must be placed in refrigerated or ventilated sections to prevent spoilage.

Example: Fresh vegetables should be stored in cooling areas, while canned goods can be placed on regular shelves.

5. **Hazardous and Allergen-Free Zones**

   Hazardous items and products with allergens must be stored separately to avoid contamination.

   Example: Cleaning detergents should not be placed near food items.

6. **Product Compatibility and Cross-Selling**

   Complementary products should be placed near each other to encourage bundled purchases.

   Example: Pasta should be stored near sauces and seasonings, while coffee should be placed near sugar and creamers.

7. **Restocking Efficiency**

   Heavy or bulky items should be placed in lower shelves for easier stocking and retrieval by staff.

   Example: Large rice bags should be on bottom shelves, while lighter cereal boxes can be placed on upper levels.

8. **Refrigeration Efficiency**

   Products requiring refrigeration should be grouped together to ensure that one refrigerator is fully utilized before using another. This reduces energy consumption and optimizes cooling efficiency.

   Example: Frozen nuggets and tender pops should be stored in the same refrigerator rather than splitting them between two, ensuring one unit is maximally utilized before opening another.

9. **Promotional and Discounted Items Visibility**

   Discounted and promotional items should be placed in highly visible locations to attract customer attention.

   Example: Buy-one-get-one-free cereal should be at the aisle entrance or checkout counters.

10. **Theft Prevention**

    To reduce shoplifting, expensive and high-theft items should be placed in secure, high-visibility areas.

    Example: Luxury perfumes, and high-end electronics should be kept in locked display cases or behind staffed counters.

Generate a Genetic Algorithm (GA) for optimal shelving plan by considering the above constraints.

Note:

Ensure the dataset includes enough products to verify each constraint. The product selection should cover different categories, storage needs, and placement rules.

Bonus:

Store the optimized shelf allocation results in an Excel sheet for better visualization and analysis. The sheet should include all required columns.

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Example:

Suppose there are 4 shelves, 1 refrigerated zone, and 1 hazardous item zone, and each shelf has its own capacity:

S1 - Checkout Display (8kg)
S2 - Lower Shelf (25kg)
S4 - Eye-Level Shelf (15kg)
S5 - General Aisle Shelf (20kg)
R1 - Refrigerator Zone (20kg)
H1 - Hazardous Item Zone (10kg)

And these are the products:

P1 - Milk (5kg), P2 - Rice Bag (10kg), P3 - Frozen Nuggets (5kg), P4 - Cereal (3kg), P5 - Pasta (2kg), P6 - Pasta Sauce (3kg), P7 - Detergent (4kg), P8 - Glass Cleaner (5kg)

Our task is to use a genetic algorithm to find a feasible and optimal schedule for storing these products in shelves

Then One Possible Solution is:

S2: Rice Bag, Pasta, Pasta Sauce (15kg)
S4: Milk, Cereal (8kg)
R1: Frozen Nuggets (5kg)
H1: Detergent, Glass Cleaner (9kg)

This solution optimally assigns products to shelves while satisfying various constraints, such as weight limits, refrigeration needs, hazardous product placement, and logical category grouping.

S2: Stores heavy and complementary items like Rice Bag , Pasta, and Pasta Sauce, supporting both weight distribution and cross-selling.
S4: Holds Milk and Cereal, ensuring high-demand products are easily accessible and logically grouped.
R1: Contains Frozen Nuggets (5kg), following the refrigeration constraint for perishable goods.
H1: Stores Detergent and Glass Cleaner in a separate hazardous area to prevent contamination with food products
This solution satisfies all constraints with a fitness score of 0, ensuring optimal shelf utilization, proper product placement, and no violations of weight, accessibility, or category grouping rules..
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GOOD LUCK 🙂