INTRODUCTION TO AI

REPORT

Agricultural land production planning:

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Introduction

In Algeria, the agricultural sector is vital, contributing significantly to the economy and food security. This report presents a solution for optimizing agricultural production, focusing on seven key products: wheat, corn, dates, potatoes, tomatoes, green peppers, and aubergines. By strategically organizing production and employing different search strategies, we aim to minimize consumer prices, maximize production, and achieve self-sufficiency effectively.

Agricultural Production Optimization Objectives:

In our agricultural production optimization project in Algeria.First and foremost, our goal is to organize agricultural production to improve various objectives. To achieve this overarching aim, we need to tackle the following specific problems:

Identification of Wilaya Specialties: Determine the unique agricultural specialties of each Wilaya in Algeria. This involves identifying the primary crops grown in each region.

Yearly Production Analysis: This involves gathering information on crop yields, production trends over time.

Land Usage Assessment: Evaluate the size of land used for agriculture in each Wilaya. This includes quantifying the total agricultural land area.

Productivity Evaluation: Assess the productivity of agricultural practices in each Wilaya. This involves measuring crop yields per unit area of land.

Consumption Analysis: Determine the country's consumption patterns for main agricultural products, including wheat, corn, dates, potatoes, tomatoes, green pepper, and aubergines.

Self-Sufficiency Assessment: Evaluate the level of self-sufficiency in the production of agricultural products. This includes comparing domestic production to national consumption levels.

Search for the Solution Comparative Analysis:

- We will compare the solutions obtained from different search algorithms, including breadth-first search (BFS), depth-first search (DFS), A* search, and steepest ascent hill climbing.
- We will analyze the efficiency and effectiveness of each algorithm in finding optimal or near-optimal solutions within a reasonable timeframe.

Cost Analysis in Terms of Time and Space Requirements:

- We will assess the computational resources required by each search algorithm, including time and space complexity.
- Time requirements will be measured in terms of the computational time taken to find a solution, while space requirements will consider the memory usage during the search process.
- Comparative analysis will help identify trade-offs between computational efficiency and solution quality, providing insights into the most suitable algorithm for our optimization problem.

Based on the comparative analyses, we will suggest the best assignment of agricultural production in Algeria, considering both the quality of solutions obtained and the computational resources required. This recommendation will guide decision-makers in implementing effective strategies to optimize agricultural production, enhance food security, and promote sustainable development in the country.

Solution Overview:

The solution involves a comprehensive approach to organize agricultural production, focusing on several key aspects:

1-Overall Structure:

The overall structure consists of three main classes: Wilaya, Product, and Year, forming a hierarchical relationship as follows: Wilaya contains information products through class product and class Year, Product stores details regarding agricultural products and its stored quantities through class Year, and class Year manages data related to yearly production, consumption, land sizes, and prices.

2-Data Management:

We have gathered comprehensive data on various aspects, including yearly consumption and production for each Wilaya (48 in total) for each of the seven primary agricultural products, prices for each season, distances of Wilayas to their neighbors, and Wilaya sizes.The data has been stored and read from CSV files, ensuring efficient management and easy access for analysis.

Reasoning for Data Selection:

Wilayas Selection (48 instead of 58):The decision to focus on 48 Wilayas instead of all 58 was deliberate and based on data consistency and availability. These 48 Wilayas were selected due to the reliability and completeness of data sources.

Years Selection (2016-2019): The choice of the years 2016 to 2019 reflects the period with the most consistent and readily available data. By narrowing our focus to these years, we ensure that our analysis is based on a robust dataset.

Formulation of Lowest Price Search Problem:

Defining Lowest Price:

The lowest price is determined by a quotient calculated as follows:

Quotient = Mean Production \ Highest Production

Idea behind it :

Although there is a correlation between higher production and lower prices in Wilayas, it is overly simplistic and potentially misleading to assume that the Wilaya with the highest production will always offer the lowest prices. Various factors, such as production efficiency and local market dynamics, influence prices. Therefore, we use the quotient to provide a more nuanced measures.

State Space:

- **Wilayas:** The state space consists of the 48 Wilayas in Algeria. Each state represents a specific Wilaya with its associated production and price data for the agricultural products.

Initial State:

- **Initial Wilaya:** The search begins from an initial Wilaya. This starting point can be any of the 48 Wilayas where the search for the lowest price begins.

Goal State:

- **lowest Price State:** The goal is to find a Wilaya where the adjusted price (defined by the quotient of mean production to highest production) is minimized and matches the target quotient for the product in the given year.

Step Cost:

- **Distance Between Wilayas:** The step cost is defined as the distance between neighboring Wilayas.

State Transition Model:

- **Possible Directions:** From a given Wilaya, the possible transitions are to its neighboring Wilayas. The possible_directions method provides a list of neighboring Wilayas, representing the state transitions in the search space**.**

Search Strategies and Heuristic Explanation:

1. **Uninformed Search Strategies:**
   - **Breadth-First Search (BFS):** Explores all possible production assignments level by level, starting from the initial Wilaya. It systematically examines all neighboring states at the present depth before moving on to nodes at the next depth level. This approach ensures that the first solution found is the shortest path, though it may be computationally expensive in terms of time and space.
   - **Depth-First Search (DFS):** Delves deeply into each possible production assignment path from the initial Wilaya. It explores as far as possible along each branch before backtracking. This method is less memory-intensive but can get stuck in deep branches and may not find the shortest path.
2. **Informed Search Strategies:**
   - ***A* Search:*** Utilizes a heuristic to guide the search more efficiently towards the goal state. The heuristic used is the quotient. This heuristic helps estimate how close a Wilaya is to achieving the target quotient also it achieves both admissibility and consistency.
   - **Steepest Ascent Hill Climbing:** Iteratively moves towards neighboring states that provide the most significant improvement in the quotient, aiming to lower the adjusted price. This method uses the steepest ascent version, which selects the neighboring state with the highest improvement.

Heuristic Function:

- **Quotient-Based Heuristic:** The heuristic function, heuristic_LP_abzk, calculates the quotient for each Wilaya:

  Heuristic Quotient = Mean Production \ Production

Idea behind it:

This heuristic leverages the observed relationship between high production and lower prices, it suggests the potential for lower prices allowing the algorithm to prioritize Wilayas with the potential for optimal price outcomes, also its ability to generate relatively small values, which tend to converge towards zero at the goal state. This convergence indicates the proximity of a Wilaya to achieving the target price quotient, facilitating the identification of optimal solutions.

- **Admissibility:** The heuristic never overestimates the cost. It provides an estimate that is always less than or equal to the true cost from the current state to the goal state.
- **Consistency:** The heuristic satisfies the triangle inequality. For any two states n, n': $h(n) \leq c(n,a,n') + h(n')$

.Formulation of the Highest Production Search Problem

Reason of choosing strategic products:

Wheat, dates, potatoes, and tomatoes are strategically chosen for highest production search in Algeria due to their pivotal roles in food security, cultural significance, and economic impact. Wheat ensures dietary needs, dates contribute to trade and cultural heritage, potatoes offer dietary diversity and farmer income, while tomatoes are integral to cuisine and agricultural output, aligning with national priorities for food security and economic growth.

State Space:

- **Wilayas:** The state space consists of the 48 Wilayas in Algeria. Each state represents a specific Wilaya with its associated production and agricultural suitability for the product in question.

Initial State:

- **Initial Wilaya:** The search begins from an initial Wilaya. This starting point can be any of the 48 Wilayas where the search for the highest production starts.

Goal State:

- **Highest Production State:** The goal is to find the Highest Production of a strategic product (wheat, dates, potatoes, tomatoes) considering the scale and quotient defined.

Step Cost:

- **Distance Between Wilayas:** The step cost is defined as the distance between neighboring Wilayas. This cost accounts for the transportation and logistical challenges in agricultural planning.

State Transition Model:

- **Possible Directions:** From a given Wilaya, the possible transitions are to its neighboring Wilayas. The possible_directions method provides a list of neighboring Wilayas, representing the state transitions in the search space.

Search Strategies and Heuristic Explanation

1. **Uninformed Search Strategies:**
   - **Breadth-First Search (BFS):** BFS explores the state space level by level, ensuring the shallowest solution is found first. It is thorough but may require significant memory to store all the states at the current level.
   - **Depth-First Search (DFS):** DFS explores each path to its fullest before backtracking. It uses less memory but can get stuck in deep branches and may miss the optimal solution if the state space is large.
2. **Informed Search Strategies:**
   - ***A* Search****:* Utilizes a heuristic to guide the search more efficiently towards the goal state. The heuristic is the quotient, calculated as the inverse of the scaled production. This heuristic helps estimate how close a Wilaya is to achieving the highest production; it also ensures both admissibility and consistency.
   - **Steepest Ascent Hill Climbing:** Iteratively moves towards neighboring states that provide the most significant improvement in production, using the heuristic to guide the search. This method uses the steepest ascent version, which selects the neighboring state with the highest improvement.

Heuristic Function:

- **Quotient-Based Heuristic:** The heuristic function, heuristic_abzk, calculates the quotient for each Wilaya:

Heuristic Quotient = 1 / (Wilaya Size× land used ×Scale)

Idea behind it:

The quotient calculation is based on the observed relationship between large land sizes and high productions in agricultural contexts. By incorporating a scale factor, making the estimation more reasonable and aligned with empirical data.The heuristic's ability to converge towards smaller quotient values at the goal state (~0) ensures accurate estimation and facilitates the identification of Wilayas with the highest production potential.

   - **Admissibility:** The heuristic never overestimates the cost, providing an estimate that is always less than or equal to the true cost from the current state to the goal state.
   - **Consistency:** The heuristic satisfies the triangle inequality. For any two states n,n′: $h(n) \leq c(n,a,n') + h(n')$

Search Algorithms Analysis:

Method used: Performance is measured over 100 trials for both time and memory using the time.perf_counter() function and tracemalloc module respectively.

1. Breadth-First Search (BFS)

Theoretical Time Complexity:

Time Complexity:O(b^d) , where b is the branching factor (average number of neighbors) and d is the depth of the shallowest solution.

Space Complexity:O(b^d) as BFS stores all nodes at the current level before moving to the next level.

Practical Results:

Average Time: 10.41 µs

Memory Usage:

Current: 136 bytes

Peak: 4472 bytes

Optimal Solution: BFS does guarante to find the optimal solution since the step cost between states is not uniform.

2. Depth-First Search (DFS)

Theoretical Time Complexity:

Time Complexity:O(b^m), where m is the maximum depth of the search tree.

Space Complexity:O(b · m), as DFS only needs to store a single path from the root to a leaf node along with the unexpanded nodes at each level.

Average Time: 9.72 µs

Memory Usage:

Current: 56 bytes

Peak: 976 bytes

Optimal Solution:DFS does not guarantee finding the optimal solution.

3. A* Search:

Theoretical Time Complexity:

Time Complexity:O(b^d) , where d is the depth of the optimal solution. The heuristic helps in reducing the number of nodes explored, but in the worst case, it can still be exponential.

Space Complexity: O(b^d), as it stores all generated nodes.

Practical Results:

Average Time:124.12 µs

Memory Usage:

Current: 276 bytes

Peak: 8752bytes

Optimal Solution: A* guarantees finding the optimal solution since the heuristic used is admissible and consistent but with a 5% margin of error.

4. Hill Climbing Search:

Theoretical Time Complexity:

Time Complexity: O(b^m), but typically faster in practice as it follows the steepest ascent and may converge quickly.

Space Complexity: O(b), since it only needs to store the current state and its neighbors.

Practical Results:

Average Time: 6.24 µs

Memory Usage:

Current: 32 bytes

Peak: 424bytes

Optimal Solution: Hill climbing does not guarantee finding the optimal solution because it may get stuck in local optima.

Comparative Analysis:

- **Time Complexity:**
    - BFS and A* have the same theoretical time complexity , but A* usually performs better in practice due to the heuristic.
    - DFS and Hill Climbing have a higher theoretical complexity in terms of the maximum depth m, but DFS can be significantly faster if the solution is deep in the tree.
    - Hill Climbing often finds solutions quickly but may not find the optimal solution.
- **Space Complexity:**
    - BFS and A* have higher space complexity due to storing all nodes at the current level or all generated nodes.
    - DFS has a lower space complexity since it stores only the current path.
    - Hill Climbing has the lowest space complexity, needing only the current state and its neighbors.
- **Practical Results:**
    - BFS and A* took more time and memory due to their extensive state exploration.
    - DFS had the second-lowest time and memory usage but doesn't always find the optimal solution.
    - Hill Climbing was the fastest and most memory-efficient but is prone to local optima.
- **Optimal Solutions:**
    - BFS and A* guarantee optimal solutions given and admissible heuristics respectively.
    - DFS and Hill Climbing do not guarantee optimal solutions.

Optimizing Agricultural Production in the Country:

In order to enhance agricultural production across the country, it is essential to focus on improving yields and efficiency within each wilaya. To achieve this, we propose a targeted approach that leverages the unique strengths and pricing advantages of each region.

The solution involves the following steps:

1. **Identifying Lowest Prices and Highest Production**: By using the search strategies stated before, we can identify which wilayas offer the lowest prices for specific agricultural products while also achieving high production levels.
2. **Leveraging Wilaya Specialties**: Each wilaya has certain crops they specialize, and we get this the information by using the wilaya_specialty.We should use this specialization to our advantage.
3. **Strategic Recommendations:**

Alignment of Specialty and Pricing:

When a wilaya offers the lowest price for Product A and also specializes in producing Product A, it indicates that the wilaya is on the right path. In such cases, the wilaya should continue to focus on this product to maintain and enhance its competitive advantage.

Realignment for Improved Focus:

If a wilaya has the lowest price for Product A but specializes in producing Product B, it suggests a need for strategic realignment. The wilaya should shift its focus more towards Product A. This adjustment will help optimize its agricultural output and contribute more effectively to the national agricultural system.

By implementing these strategic recommendations, we can ensure that each wilaya is maximizing its agricultural potential. This will lead to overall improvements in the country's agricultural production, ensuring a more efficient and productive agricultural sector.

References

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WORK DISTRIBUTION :

Team Members	work
Mokhtari Zakaria	-class Year -class product -self sufficiency function -price problem class -lowest price search implementation -heuristic for lowest price -objective function of hill climbing for lowest price search -debugging logic/code/data error encounters -reading products prices csv data -reading production (sorted+mean) /land sizes/productivity csv data -reading consumption csv data -introduction/agricultural production optimization objectives / solution overview (report) -formulation of lowest price problem (report) -search strategies and heuristic explanation (report) -analysis of BFS/DFS/A*/HILL-CLIMBING for lowest price search problem (report) -Optimizing Agricultural Production in the Country(report)
Aichi Abderrahmene	-class Wilaya -wilaya specialty function -production problem class -highest production search implementation -heuristic for highest production -objective function of hill climbing for highest production search -wilaya neighbors (wilayas graph) -debugging logic/code/data error encounters -reading wilaya sizes data -wilaya costs data -formulation of highest production problem (report) -search strategies and heuristic explanation (report) -analysis of BFS/DFS/A*/HILL-CLIMBING for highest production search problem (report) -Optimizing Agricultural Production in the Country(report)

Dib Ishak	-wilayas production data(sorted+mean) /landsizes/productivity data from 2018-2019 -prices data from 2018-2019 -country yearly production/consumption data from 2018-2019 -wilaya distances data -data references(report)
Mahmoudi Mohamed Eyad	-wilayas production data(sorted+mean) /land sizes/productivity data from 2016-2017 -prices data from 2016-2017 -country yearly production/consumption data from 2016-2017 -wilaya sizes data -wilaya distances data -data references(report)