ESILV
ENGINEERING SCHOOL
DE VINCI PARIS NANTES

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Artificial Intelligence Algorithms

MESIIN476024

Project statement : Technical interview

Table des matières

1 Preamble

This project replicates a task assigned during a technical interview, as part of a recruitment process for a major French company. The goal was to secure a position as a Research Engineer in Data Science & Optimization. The task was given to the candidate four days before a technical interview with the company's expert panel. During this time, the candidate was expected to familiarize themselves with the problem, define it formally, and develop effective solutions based on AI algorithms.

The project mirrors the information and resources provided to the candidate, without adding any additional elements beyond the original task description.

The question now is : Can you rise to the challenge of this recruitment phase and secure a position at this prestigious French company by applying the knowledge and skills you've gained from the AI algorithms course ?

2 Problem Description

A biscuit manufacturing factory is planning to produce a series of biscuits for Christmas. Using the same roll of dough, the factory aims to create various biscuits of different sizes and shapes. The goal is to maximize biscuit production from a single roll while ensuring the highest possible profit.

To achieve this goal, we have the following information :

- The roll of dough has a predefined rectangular length, referred to as 'LENGTH', representing a one-dimensional problem.
- The roll may contain irregularities, referred to as defects. Each defect has
  - a position 'x'
  - and a class, which could be one of several types (*e.g.*, 'a', 'b', 'c', ...).
- The factory aims to produce a set of biscuits. Each Biscuit can be produced an infinite number of times, and has :
  - a specific size (along the same dimension as the roll)
  - a value (price)
  - and a threshold for the maximum number of defects of each class it can contain (otherwise it cannot be marketed).

A solution is defined as an arrangement of biscuits along the dough roll. For an arrangement (assignment) to be valid, it must satisfy the following conditions :

- Biscuits must be placed at integer positions.
- No overlapping of biscuits is allowed. For example, if you place a biscuit B1 of size 3 at position 'x=2', no other biscuit can be assigned to positions 'x=3' or 'x=4'.
- Each biscuit placed must contain fewer defects (or an equal number) of each class than its permitted thresholds. For instance, if biscuit B1 of size 3 is placed at 'x=2', it covers positions 2, 3 and 4. If there are 3 defects of class 'a' in these positions, but B1's threshold for class 'a' is a maximum of 2 defects, then the assignment is invalid.
- The total size of the assigned biscuits must not exceed the length of the dough roll.

The value of a solution is the sum of the individual values of the biscuits placed on the roll. However, any portion of the dough roll without an assigned biscuit incurs a penalty of -1 per position, reflecting the company's loss from wasted material. This penalty is subtracted from the overall value of the solution.

Benchmark

For this project, the following assumptions are made :

- The length of the roll of dough is set to 500 units.
- The roll has three classes of defects ('a', 'b', and 'c'). The set of defects and their positions on the roll are available in the 'defects.csv' file.
- The biscuit manufacturing factory aims to produce 4 types of biscuits :
  - Biscuit 0 with a length of 4, a value of 3, and maximum allowed defects as $\{'a' : 4, 'b' : 2, 'c' : 3\}$
  - Biscuit 1 with a length of 8, a value of 12, and maximum allowed defects as $\{'a' : 5, 'b' : 4, 'c' : 4\}$
  - Biscuit 2 with a length of 2, a value of 1, and maximum allowed defects as $\{'a' : 1, 'b' : 2, 'c' : 1\}$
  - Biscuit 3 with a length of 5, a value of 8, and maximum allowed defects as $\{'a' : 2, 'b' : 3, 'c' : 2\}$

3 Project Objectives

This section outlines the primary goals of the project, focusing on a comprehensive understanding and addressing the challenges of the problem.

1. **Describe the problem and its challenges.**
   — Clearly articulate the problem at hand and identify the specific challenges it presents. This includes describing the problem, outlining the constraints and stating the goals of the project.
2. **Formulate and implement the problem using Python.**
   — Detail the steps taken to translate the problem into a solvable format using Python. Explain the reasoning behind each step and the motivations for the choices made during implementation.
3. **Propose two alternative problem-solving approaches.**
   — Present two **distinct** methods for addressing the problem. Example : Uninformed or Informed search solutions, heuristic methods, local search or constraint satisfaction problem tecnhiques. Provide justification for why each method was selected and how it is relevant for solving the problem.
   — You can provide heuristics or approaches that compute a feasible or optimal solution.
   — Compare the two proposed approaches in terms of performance (execution time, quality of the proposed solution, etc.)
4. **Conclusion and reflections :**
   — Summarize what this project has contributed to your learning experience. Discuss the challenges encountered during the project and how they were addressed. Reflect on any aspects of the project that were particularly insightful or noteworthy.

4 Project Deliverables

As part of the project, you are required to submit the following :

— **Final Presentation.** The project includes a presentation, which will **take place during the final Lab session**. In this presentation, you will be required to provide a detailed explanation of your solution. This will cover the description of the problem, the formalization of the problem and key implementation choices, a description and justification of the two developed solution approaches, as well as a discussion of the results, including performance analysis and key insights. Further details regarding the format and organization of the presentation will be communicated in the near future.

— **Jupyter Notebook Submission.** Along with the presentation, you are required to submit a **Jupyter notebook** containing the code used to implement the problem and your solutions. The notebook must include the following components :
   — **Implementation choices :** A detailed explanation of the core implementation decisions made throughout the project. This should include the reasoning behind the chosen formalism and structure used to represent the problem.
   — **Problem-Solving Approaches :** A comprehensive overview of the techniques and methods employed to tackle the problem. Whether you used heuristic algorithms, local search methods, constraint satisfaction techniques, or AI-related strategies, explain each method and how it contributes to the overall solution.
   — **Results and Performance Analysis :** A thorough evaluation of the solution's performance. This section should include metrics such as execution time, solution quality, and other relevant performance indicators. Provide a discussion of your solution's strengths, along with suggestions for potential improvements.
   — **Final Reflections :** Summarize your overall experience with the project. Reflect on the challenges you encountered, areas where you might have done things differently, and the key learning outcomes. Highlight any insights or observations you found particularly valuable during the project.
— The deadline for submitting your notebook is **Friday, December 13th**. **Please make sure to include the materials for your presentation.**

Both the presentation and notebook will play a pivotal role in demonstrating your understanding of the problem, your decision-making process, and your ability to communicate technical solutions effectively.

5 Challenge Overview

The original candidate had only four days to comprehend and propose a solution to the problem. You will have slightly more than a month to accomplish this task. Can you rise to the challenge and secure a position at this prestigious French company by demonstrating your problem-solving skills ?

6 Project Guidelines and Rules

- **Group Work :** The project must be completed in groups of up to three participants. Please use the following link "click here" to enter the names of your team members. The deadline to complete this file and finalize your teams is November 10th. Make sure to enter your team information on the correct sheet corresponding to your Lab group.
- **Submission Deadline :** All project materials must be submitted by the stated deadline. Late submissions will not be accepted.
- **Originality :** Each project must be the original work of the team. Plagiarism or copying from other sources is strictly prohibited.
- **Bonus Points :** A bonus of up to two points will be awarded to any work that demonstrates innovation, creativity, or thoroughness in presenting and solving the problem.
- **Unexplained Code Policy :** Any submitted code that lacks necessary explanations, comments, or documentation will not be evaluated (graded). It is essential to provide clear documentation and rationale for your coding choices.