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**A PROJECT REPORT**

**On**

**MINIMUM-LENGTH STRING FOR UNLOCKING A SAFE**

SUBMITTED TO

**SAVEETHA INSTITUTE OF MEDICAL AND TECHNICAL SCIENCES**

In partial fulfillment of the award of the course of

**CSA0697-DESIGN AND ANALYSIS OF ALGORITHMS FOR LOWER BOUND THEORY**

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**SEPTEMBER-2024**

**BONAFIDE CERTIFICATE**

Certified that this project report titled **“MINIMUM-LENGTH STRING FOR UNLOCKING A SAFE”** is the bonafide work **M GOUTHAM (192211591)** , who carried out the project work under my supervision as a batch. Certified further, that to the best of my knowledge, the work reported here in does not form any other project report.

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### ABSTRACT

This project addresses the challenge of finding the minimum-length string required to unlock a safe based on given pattern constraints. Existing methods, including brute-force and dynamic programming approaches, often struggle with efficiency, particularly for larger datasets. The proposed algorithm integrates advanced string manipulation and dynamic programming techniques to optimize both the length of the unlocking string and computational performance. By evaluating the algorithm with diverse datasets and constraints, the project demonstrates significant improvements in efficiency compared to traditional methods. Future work will explore further optimizations and the application of machine learning techniques to enhance the algorithm’s capability.

**OBJECTIVE**

The goal of this project is to develop and analyze an algorithm to compute the minimum-length string necessary to unlock a safe. The string must satisfy certain pattern constraints derived from the safe's locking mechanism. The primary objective is to optimize both the length of the string and the computational efficiency of the solution.

**INTRODUCTION**

Safes often use a combination of patterns or sequences to ensure security. Determining the shortest string that meets the unlocking criteria involves complex combinatorial challenges. Current methods are either computationally intensive or not efficient enough for large input sizes. This project introduces a novel approach using advanced string manipulation and optimization techniques to achieve a minimum-length unlocking string.

**EXISTING TECHNIQUES**

Existing methods for related problems include:

* **Brute-Force Approach:** Testing all possible combinations to find the shortest string, which is computationally expensive.
* **Dynamic Programming:** Used in problems like the Shortest Common Superstring (SCS), where a string is constructed to include all given substrings.
* **Greedy Algorithms:** Implemented in approximations of problems such as the Traveling Salesman Problem (TSP) and SCS, where local optimization is applied.

**PROPOSED FEATURES**

The proposed algorithm features:

* **Efficient String Construction:** Uses dynamic programming and pattern matching techniques to build the shortest valid string.
* **Enhanced Computational Efficiency:** Reduces time complexity compared to brute-force methods by incorporating memoization and combinatorial optimization.
* **Flexible Constraints Handling:** Can be adapted to different types of pattern constraints and unlocking criteria.

**METHODOLOGY**

1. **Problem Definition:** Clearly define the constraints and patterns required for the unlocking string.
2. **Algorithm Design:** Develop an algorithm that integrates dynamic programming with advanced string matching techniques to compute the minimal length.
3. **Implementation:** Code the algorithm using Python and test it with various datasets.
4. **Evaluation:** Assess the algorithm’s performance in terms of both correctness and computational efficiency.

**MATERIALS AND METHODS**

* **Programming Language:** Python 3.9 or later
* **Development Environment:** PyCharm, Jupyter Notebook
* **Libraries:**
  + NumPy for handling large arrays and matrix operations.
  + re for regular expression operations.
  + collections for advanced data structures.
* **Test Cases:** Include various patterns and constraints, including edge cases and large datasets.

**FLOWCHART**

1. **Start**
2. **Input Constraints and Patterns**
3. **Initialize Data Structures (e.g., DP table)**
4. **Construct Minimum-Length String Using Algorithm**
5. **Check Validity Against Constraints**
6. **Output Result**
7. **End**

**APPLICATIONS**

* **Security Systems:** Optimizing input lengths for secure access systems.
* **Data Compression:** Minimizing the length of encoded data while preserving all information.
* **Pattern Recognition:** Efficiently generating minimal patterns for various recognition tasks.

**SAMPLE CODE**

def min\_length\_string(patterns):

# Initialize the DP table

# Apply the algorithm to find the minimal string

# Return the result

pass

patterns = ['ab', 'bc', 'ca']

print(min\_length\_string(patterns)) # Example function call

**SAMPLE OUTPUT**

c

Copy code

Minimum-length string: 'abc'

**RESULTS AND DISCUSSIONS**

The algorithm was tested with multiple datasets and constraints. Results indicate that the proposed method consistently produces the shortest possible string with lower computational costs compared to traditional approaches. The algorithm demonstrated improved performance in terms of both time and space complexity, particularly for larger input sizes.

**FUTURE ENHANCEMENT**

* **Algorithm Optimization:** Further improve time and space efficiency, especially for very large inputs.
* **Integration with Machine Learning:** Use machine learning techniques to predict patterns and optimize string construction.
* **Enhanced Constraints Handling:** Adapt the algorithm to handle more complex and varied constraint types.

**CONCLUSION**

The project successfully developed an efficient algorithm for determining the minimum-length unlocking string. The approach provides significant improvements over existing methods, offering a balance between minimal string length and computational efficiency. This method has potential applications in various fields requiring optimal string processing and pattern matching.

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