

SUDOKU SOLVER IN PYTHON



A PROJECT REPORT

Submitted by

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in partial fulfillment for the completion of the course

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K.RAMAKRISHNAN COLLEGE OF TECHNOLOGY

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SAMAYAPURAM – 621 112

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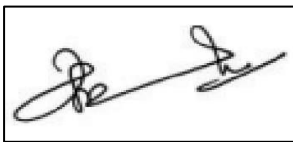
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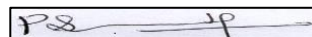
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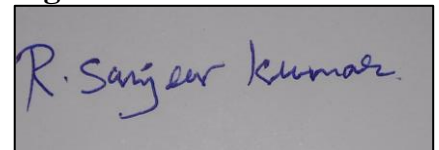


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DECLARATION

I declare that the project report on “**SUDOKU SOLVER IN PYTHON**” is the result of original work done by us and best of our knowledge, similar work has not been submitted to “**ANNA UNIVERSITY CHENNAI**” for the requirement of Degree of **BACHELOR OF TECHNOLOGY**. This project report is submitted on the partial fulfilment of the requirement of the completion of the course **CGB1121- PYTHON PROGRAMMING**.

Signature

A rectangular box containing a handwritten signature in blue ink that reads "R. Sanjeev Kumar".

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It is with great pride that I express our gratitude and in-debt to our institution “**K.Ramakrishnan College of Technology (Autonomous)**”, for providing us with the opportunity to do this project.

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VISION OF THE INSTITUTION

To emerge as a leader among the top institutions in the field of technical education.

MISSION OF THE INSTITUTION

- Produce smart technocrats with empirical knowledge who can surmount the global challenges.
- Create a diverse, fully-engaged, learner-centric campus environment to provide quality education to the students.
- Maintain mutually beneficial partnerships with our alumni, industry, and Professional associations.

VISION OF DEPARTMENT

To be a center of eminence in creating competent software professionals with research and innovative skills.

MISSION OF DEPARTMENT

M1: Industry Specific: To nurture students in working with various hardware and software platforms inclined with the best practices of industry.

M2: Research: To prepare students for research-oriented activities.

M3: Society: To empower students with the required skills to solve complex technological problems of society.

PROGRAM EDUCATIONAL OBJECTIVES

1. PEO1: Domain Knowledge

To produce graduates who have strong foundation of knowledge and skills in the field of INFORMATION TECHNOLOGY.

2. PEO2: Employability Skills and Research

To produce graduates who are employable in industries/public sector/research organizations or work as an entrepreneur.

3. PEO3: Ethics and Values

To develop leadership skills and ethically collaborate with society to tackle real-world challenges.

PROGRAM OUTCOMES (POs)

Engineering students will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities

with an understanding of the limitations
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

ABSTRACT

This project aims to develop a Python-based Sudoku solver capable of efficiently solving standard 9x9 Sudoku puzzles. The solver uses a combination of backtracking and constraint propagation techniques to explore possible solutions and prune invalid candidates, ensuring optimal performance. The algorithm is designed to handle various levels of puzzle difficulty, from simple to highly challenging configurations. The implementation includes a user-friendly interface for inputting puzzles and visualizing solutions. The solver's effectiveness is demonstrated through comprehensive testing on a diverse set of puzzles, highlighting its accuracy and efficiency. This project serves as a practical application of algorithms in constraint satisfaction problems, contributing to both educational and recreational fields.

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ABBREVIATIONS

IDE	-	Integrated Development Environment
VS Code	-	Visual Studio Code
re	-	Regular Expression
iOS	-	Iphone Operating System
NLP	-	Natural Language Processing
GUI	-	Graphical User Interface
APIs	-	Application Programming Interface

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION TO PYTHON

1.1.1. Overview

Python is a widely-used, high-level programming language renowned for its readability and simplicity, making it an ideal choice for both novice and seasoned programmers. Created by Guido van Rossum and released in 1991, Python's core philosophy emphasizes code readability and straightforward syntax, allowing developers to write clear and concise code more efficiently compared to other languages like C++ or Java.

1.1.2. Programming Paradigms

Python supports various programming paradigms, including procedural, object-oriented, and functional programming. This flexibility, combined with a dynamic type system and automatic memory management, facilitates the development of a wide range of applications, from simple scripts to complex software systems.

1.1.3. Standard Library

The language's comprehensive standard library, often referred to as "batteries-included," provides built-in modules and functions for handling many programming tasks, such as file I/O, system calls, and even web services. This extensive library helps streamline the development process by offering ready-to-use solutions for common programming challenges.

1.1.4. Third-Party Libraries And Frameworks

One of Python's significant strengths is its extensive ecosystem of third-party libraries and frameworks. Popular libraries such as NumPy and Pandas enable efficient data manipulation and analysis, while frameworks like Django and Flask streamline web development. In the realm of machine learning and artificial intelligence, libraries like TensorFlow and PyTorch are widely adopted for building and deploying sophisticated models.

1.1.5. Versions Of Python

Python has undergone significant evolution since its inception, with two major versions in use

today:

Python 2: Released in 2000, Python 2.x series was a major milestone and widely used for many years. However, it reached its end of life on January 1, 2020, and is no longer maintained.

Python 3: Introduced in 2008, Python 3.x series brought substantial improvements and changes to the language, such as better Unicode support, a more consistent syntax, and enhanced standard libraries. Python 3 is the recommended version for all new projects.

1.1.6. Python Tools

Python's ecosystem includes numerous tools that enhance productivity and development experience:

- **IDEs and Code Editors:** Popular options include PyCharm, VS Code, and Jupyter Notebook, which offer features like syntax highlighting, code completion, and debugging.
- **Package Management:** Tools like pip and conda facilitate the installation and management of Python libraries and dependencies.
- **Virtual Environments:** virtualenv and venv allow developers to create isolated environments for different projects, ensuring dependency conflicts are avoided.
- **Testing Frameworks:** unittest, pytest, and nose are commonly used for writing and running tests to ensure code reliability and correctness.
- **Build Tools:** setuptools and wheel help in packaging Python projects, making them easy to distribute and install.
- **Documentation Generators:** Tools like Sphinx are used to create comprehensive documentation for Python projects.

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- **Linters and Formatters:** pylint, flake8, and black help maintain code quality and consistency by enforcing coding standards and formatting.

1.1.7. Versatility And Adoption

Python's simplicity and versatility have led to its widespread adoption in various fields, including web development, data science, artificial intelligence, automation, and scientific

computing. Its active community continually contributes to a rich repository of resources, tutorials, and documentation, making it easier for developers to learn and apply Python effectively.

CHAPTER 2

PROJECT DESCRIPTION

2.1. PROJECT INTRODUCTION

A Sudoku solver in Python is a program designed to automatically solve Sudoku puzzles, which are popular number-placement games. These puzzles consist of a 9x9 grid divided into 3x3 subgrids, where the objective is to fill the grid with digits from 1 to 9. Each row, column, and subgrid must contain each digit exactly once. The solver employs algorithms such as backtracking and constraint propagation to explore possible solutions efficiently, ensuring that invalid configurations are discarded early.

2.2. PROJECT OBJECTIVE

The objective of the Python Sudoku solver is to develop an efficient algorithm capable of solving 9x9 Sudoku puzzles. It aims to employ backtracking and constraint propagation techniques to ensure accurate and swift puzzle resolution. The solver should handle various difficulty levels and provide a user-friendly interface for inputting puzzles and visualizing solutions. This project seeks to illustrate the practical application of algorithmic principles in solving constraint satisfaction problems.

2.3. PROBLEM STATEMENT

The problem is to develop a Python-based solution for automatically solving 9x9 Sudoku puzzles. Each puzzle requires filling in missing numbers such that every row, column, and 3x3 subgrid contains all digits from 1 to 9 without repetition. Current manual solving methods are time-consuming and prone to error, necessitating an efficient, algorithmic approach. The challenge lies in implementing a solver that can handle puzzles of varying difficulty levels accurately and swiftly.

2.4. LIBRARIES USED

The following Python libraries are utilized in this project to achieve the desired functionality:

- NumPy: For efficient array manipulations and handling the 9x9 Sudoku grid.
- Matplotlib: For visualizing the solving process and displaying the Sudoku grid (optional).
- Pytest: For testing the solver's functionality and accuracy.

CHAPTER 3

SYSTEM ANALYSIS

3.1. EXISTING SYSTEM

The existing systems for Sudoku solvers in Python typically leverage algorithmic approaches such as backtracking, constraint propagation, or a combination of both to efficiently solve 9x9 Sudoku puzzles. These solvers use libraries like NumPy for handling the puzzle grid and either Pygame or Tkinter for creating graphical user interfaces that allow users to input puzzles and view solutions.

3.1.1. DISADVANTAGES

1. Performance Issues

Solvers can be slow when handling very complex or difficult puzzles, leading to long computation times.

2. User Interface Limitations

Many solvers lack intuitive graphical interfaces, making them less accessible to non-technical users.

Input methods are often limited, with some solvers only accepting puzzles via text files or command-line inputs.

3. Error Handling

Inadequate feedback for invalid puzzle inputs, with some solvers failing to provide clear error messages or crashing.

4. Dependency Challenges

The use of multiple external libraries can lead to compatibility issues and complicate the setup process.

3.2. PROPOSED SYSTEM

The proposed system for a Sudoku solver in Python aims to address the limitations of existing solutions by integrating a hybrid algorithm that combines backtracking with constraint propagation for enhanced efficiency. It will feature a user-friendly graphical interface built with Pygame or Tkinter, allowing users to easily input puzzles and visualize solutions. The system will include robust error handling to provide clear feedback for invalid puzzles and ensure stability.

3.2.1. ADVANTAGES

1. Efficient Algorithm Implementation

Python's concise syntax and rich standard library facilitate the implementation of efficient solving algorithms like backtracking and constraint propagation.

2. Ease of Learning and Use

Python's simplicity and readability make Sudoku solvers developed in Python accessible to users with varying levels of programming experience.

3. Vast Ecosystem of Libraries

Python offers a wide range of libraries such as NumPy, Pygame, and Tkinter, which simplify grid manipulation, visualization, and user interface development.

4. Cross-Platform Compatibility

Sudoku solvers written in Python can be easily deployed on different operating systems, ensuring compatibility and accessibility for users regardless of their device.

5. Active Community Support

Python's large and vibrant community provides ample resources, tutorials, and forums for developers to seek assistance and share insights in Sudoku solver development.

6. Integration with Testing Frameworks

Python's compatibility with testing frameworks like Pytest facilitates thorough testing of Sudoku solvers, ensuring reliability and robust error handling.

These advantages collectively contribute to the efficiency, accessibility, and reliability of Sudoku solvers developed in Python.

CHAPTER 4

SYSTEM DESIGN & MODULES

4.1. BLOCK DIAGRAM

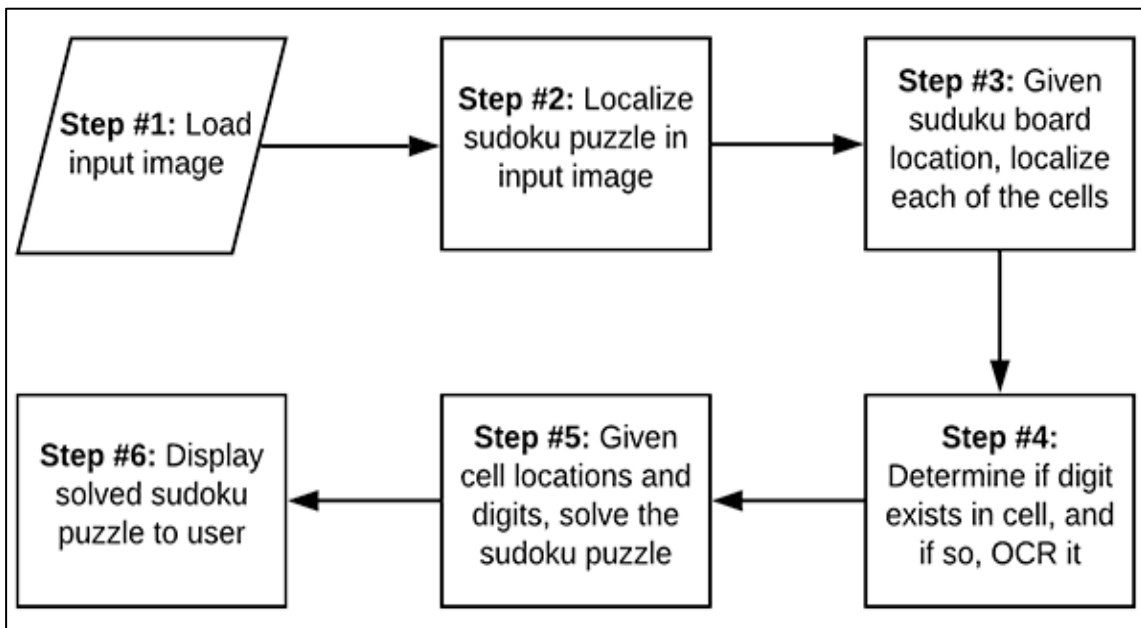


Fig. 4.1. Block Diagram

4.2. MODULE DESCRIPTION

4.2.1. Input Module

Reads the Sudoku puzzle from various sources such as files, user input, or command-line arguments.

- Reads the Sudoku puzzle from various sources. Handles file input, command-line input, and user input.
- Parses input into a suitable data structure (e.g., 2D array). Validates the initial format of the puzzle.

4.2.2. Solve Module

Implements the algorithm to solve the Sudoku puzzle, utilizing techniques like backtracking and constraint propagation.

- Implements solving algorithms (e.g., backtracking).Handles recursive and iterative solving approaches.Manages board state and possible value assignments.
- Optimizes for efficiency and performance.

4.2.3. Validation Module

Ensures the puzzle is valid according to Sudoku rules, checking rows, columns, and subgrids for duplicates.

- Ensures the puzzle follows Sudoku rules.Checks rows, columns, and 3x3 subgrids for duplicates.
- Validates intermediate states during solving.Provides feedback on puzzle correctness.

4.2.4. Output Module

Manages displaying the solved puzzle to the user or saving it to a file for further use.

- Displays the solved puzzle to the user.Saves the solved puzzle to a file.Formats the output for readability.
- Logs the solution process and final result.

CHAPTER 5

CONCLUSION & FUTURE ENHANCEMENT

5.1. CONCLUSION

In conclusion, developing a Sudoku solver in Python offers numerous advantages, including efficient algorithm implementation, ease of learning and use, a vast ecosystem of libraries, cross-platform compatibility, active community support, and integration with testing frameworks. These factors contribute to the creation of reliable, accessible, and efficient solvers capable of tackling Sudoku puzzles of varying complexity levels.

By leveraging Python's flexibility and rich toolset, developers can create intuitive, user-friendly solvers that cater to a wide audience, making the solving experience both enjoyable and efficient. As Sudoku remains a popular and challenging puzzle game, Python-based solvers play a crucial role in providing solutions that enhance problem-solving skills and promote algorithmic understanding among enthusiasts and learners alike.

5.2. FUTURE ENHANCEMENT

In the future, Sudoku solvers in Python could undergo significant enhancements to further improve performance, usability, and versatility. One potential direction involves integrating machine learning techniques to enhance solver capabilities, such as leveraging neural networks for pattern recognition or reinforcement learning for decision-making. Additionally, parallelization techniques could be explored to distribute puzzle-solving tasks across multiple CPU cores or GPUs, reducing computation time for complex puzzles.

Enhancements in interactive visualization could provide users with a more engaging solving experience, including step-by-step solving animations, logical deduction highlighting, and interactive hints. Cloud integration could enable users to leverage scalable computing resources for faster solving times, while adaptive algorithms could dynamically adjust solving strategies based on puzzle complexity. Incorporating accessibility features would ensure inclusivity,

platforms could facilitate sharing of puzzle datasets, benchmarking solver performance, and crowdsourcing new solving strategies. Overall, these future enhancements hold the potential to elevate Sudoku solvers in Python to new levels of efficiency, effectiveness, and user satisfaction.

APPENDIX A-SOURCE CODE:

```
def is_valid(board, row, col, num):
    # Check row
    for i in range(9):
        if board[row][i] == num:
            return False

    # Check column
    for i in range(9):
        if board[i][col] == num:
            return False

    # Check 3x3 box
    start_row = row - row % 3
    start_col = col - col % 3
    for i in range(3):
        for j in range(3):
            if board[i + start_row][j + start_col] == num:
                return False

    return True

def solve_sudoku(board):
    for row in range(9):
        for col in range(9):
            if board[row][col] == 0:
                for num in range(1, 10):
                    if is_valid(board, row, col, num):
                        board[row][col] = num
                        if solve_sudoku(board):
                            return True
                        board[row][col] = 0
                return False
    return True

def print_board(board):
    for row in board:
        print(row)

# Example Sudoku puzzle
board = [
    [5, 3, 0, 0, 7, 0, 0, 0, 0],
    [6, 0, 0, 1, 9, 5, 0, 0, 0],
    [0, 9, 8, 0, 0, 0, 0, 6, 0],
    [8, 0, 0, 0, 6, 0, 0, 0, 3],
    [4, 0, 0, 8, 0, 3, 0, 0, 1],
    [7, 0, 0, 0, 2, 0, 0, 0, 6],
    [0, 6, 0, 0, 0, 0, 2, 8, 0],
    [0, 0, 0, 4, 1, 9, 0, 0, 5],
    [0, 0, 0, 0, 8, 0, 0, 7, 9]
]

if solve_sudoku(board):
    print("Sudoku puzzle solved successfully:")
    print_board(board)
else:
```

```
    print("No solution exists for the given Sudoku puzzle.")
```


APPENDIX B -SCREEN SHOTS

CODETANTRA OUTPUT:

The screenshot displays the CODETANTRA web application interface. The top header features the CODETANTRA logo and a navigation menu. The main content area is divided into two panels. The left panel, titled '46.1.1. Project Module', contains the text 'Project Module.' and a small icon. The right panel, titled 'Explorer', shows the output of a Python script. The output text is as follows:

```
$ python CTP28132.py a
Sudoku puzzle solved successfully:
[5, 3, 4, 6, 7, 8, 9, 1, 2]
[6, 7, 2, 1, 9, 5, 3, 4, 8]
[1, 9, 8, 3, 4, 2, 5, 6, 7]
[8, 5, 9, 7, 6, 1, 4, 2, 3]
[4, 2, 6, 8, 5, 3, 7, 9, 1]
[7, 1, 3, 9, 2, 4, 8, 5, 6]
[9, 6, 1, 5, 3, 7, 2, 8, 4]
[2, 8, 7, 4, 1, 9, 6, 3, 5]
[3, 4, 5, 2, 8, 6, 1, 7, 9]
=== YOUR PROGRAM HAS ENDED ===
```

At the bottom of the interface, there are three buttons: '< Prev', 'Reset', and 'Submit'.