UNIVERSITY OF LAYYAH

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SEMESTER PROJECT REPORT

Department INFORMATION TECHNOLOGY

Sudoku Game Puzzle

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- **Acknowledgment**

We extend our gratitude to our instructor, [Instructor’s Name], for their guidance throughout this project. Their insights and encouragement helped us overcome challenges and achieve the desired outcomes. Additionally, we thank [Institution Name] for providing resources and support, making this project possible.

Summary

This project aimed to create a Sudoku game using advanced data structures and algorithms. Sudoku, a logic-based number puzzle, challenges players to fill a grid with numbers from 1 to 9, ensuring no repetition in rows, columns, or sub-grids.

Key objectives included generating valid puzzles, implementing an efficient solver, and designing an interactive interface. Using Python, we developed a game with a random puzzle generator, a recursive backtracking solver, and an intuitive graphical interface.

Challenges involved ensuring unique solutions for generated puzzles, optimizing the solver for complex grids, and making the interface user-friendly. Extensive testing ensured that the game met these requirements. The project demonstrates how data structures and algorithms can be applied to solve real-world problems effectively.

Introduction

What is Sudoku?

Sudoku is a widely popular puzzle game that consists of a 9x9 grid divided into nine 3x3 sub-grids. The player must fill empty cells in such a way that every row, column, and sub-grid contains all numbers from 1 to 9.

Project Motivation:

Sudoku puzzles are not just recreational; they offer opportunities to apply computational techniques. By implementing this project, we explored problem-solving with backtracking algorithms and optimized data structures for efficiency.

Scope of the Project:

This project involves creating a standalone Sudoku game that:

- Generates solvable puzzles.
- Allows users to solve puzzles interactively.
- Offers an automated solver to check user solutions.

- **Objectives**

- **Game Functionality**: Create a user-friendly Sudoku game with interactive features like highlighting, error detection, and difficulty selection.
- **Puzzle Generation**: Ensure puzzles are randomly generated, valid, and have unique solutions.
- **Algorithm Efficiency**: Implement a solver using a backtracking algorithm optimized for performance.
- **Educational Outcome**: Enhance our understanding of data structures like arrays, matrices, and recursion.

- **Tools and Technologies**

- **Programming Language**: Python – chosen for its simplicity and powerful libraries.

- **Development** Environment: PyCharm – for efficient code writing and debugging.

- **Libraries**:

NumPy: Used for array manipulations.

Pygame: To create a graphical interface for the game.

- **Version Control:** GitHub – for code management and collaboration.

- **Methodology**

Problem Analysis

We began by understanding Sudoku rules and constraints. This analysis helped us design a data model that stores the board state and checks constraints effectively.

Algorithm Design

A recursive backtracking algorithm was chosen for its ability to explore all possible solutions systematically.

Constraints: The algorithm ensures that numbers placed in cells do not violate Sudoku rules.

Efficiency Improvements: Pruning techniques were used to reduce unnecessary computations by checking constraints before proceeding.

Game Design

The game interface was designed to allow users to:

- Input numbers by clicking on cells.
- Validate their solution.
- Reset or generate a new puzzle.

Testing

Unit Testing: Ensured each function worked correctly (e.g., valid placement checks).

Integration Testing: Verified the puzzle generator, solver, and UI modules functioned cohesively.

- **Implementation**

Puzzle Generator

- Random Placement: Numbers were randomly placed while ensuring validity.

- Uniqueness Check: The generator guarantees that the puzzle has a unique solution by running the solver after generating the board.

Solver Algorithm

- Recursive Backtracking:

Attempts placing numbers in empty cells.

If a placement leads to a conflict, it backtracks and tries the next number.

- Constraint Validation: Checks rows, columns, and sub-grids before placing a number.

User Interface

- Interactive Grid:

Users can click cells to input numbers.

Incorrect inputs are highlighted in red.

- Features:

Difficulty levels (easy, medium, hard).

Timer to track solving time.

Reset and solve options.

- **Results**

Board Generation

Puzzles were generated quickly and ensured to have a unique solution.

Users could choose difficulty levels, with harder puzzles having fewer clues.

Solver Efficiency

The solver solved puzzles in milliseconds, even for the most challenging cases.

User Experience

Feedback from testers indicated the interface was intuitive and enjoyable.

Features like error highlighting and solving assistance were well-received.

- **Challenges**

Optimization Issues

The initial solver algorithm was inefficient for hard puzzles. By introducing constraint checking and reducing recursion depth, we improved performance significantly.

User Interface Challenges

Early versions of the UI had bugs, such as unresponsive cells and misaligned grids. Extensive debugging and iterative redesign resolved these issues.

Conclusion

The Sudoku Game Puzzle project successfully demonstrated the application of data structures in a real-world scenario. By leveraging algorithms and computational techniques, we created a game that is both functional and enjoyable.

This project not only met its objectives but also enhanced our problem-solving skills and understanding of data structures. The knowledge gained will be valuable for future academic and professional endeavors.

References

- [**Author Name], Data Structures and Algorithms in Python**. [Publisher], [Year].

- **"Sudoku Puzzle Rules and Strategies."** [URL].

- **Python Documentation:** https://www.python.org/doc/

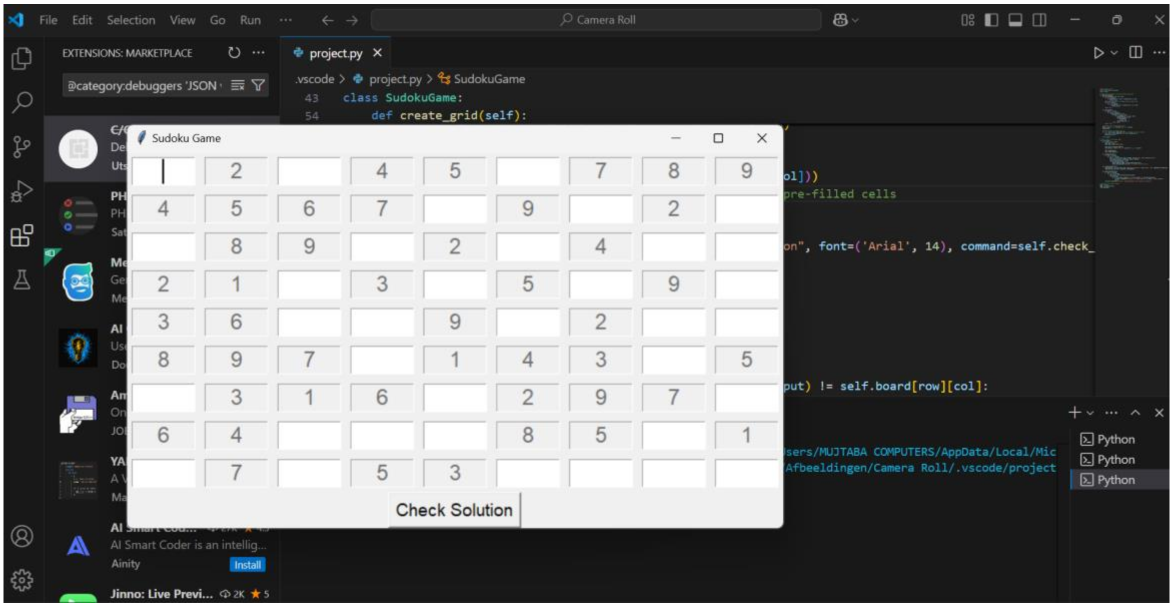
- **Pygame Documentation:** https://www.pygame.org/docs/

Appendices

Appendix A: Screenshots of the game interface.

Appendix B: Sample code for the puzzle solver.

Appendix C: Test cases and results.



```
class SudokuGame:
    def create_grid(self):
```

```
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```

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```

	2		4	5		7	8	9
4	5	6	7		9		2	
	8	9		2		4		
2	1		3		5		9	
3	6			9		2		
8	9	7		1	4	3		5
	3	1	6		2	9	7	
6	4				8	5		1
	7		5	3				

```
import tkinter as tk

from tkinter import messagebox

import random


# Sudoku puzzle generator using backtracking algorithm

def generate_sudoku():

    def is_valid(board, row, col, num):
```

```
    for i in range(9):
        if board[row][i] == num or board[i][col] == num:
            return False
    start_row, start_col = 3 * (row // 3), 3 * (col // 3)
    for i in range(3):
        for j in range(3):
            if board[start_row + i][start_col + j] == num:
                return False
    return True

def solve(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(board):
                            return True
                        board[row][col] = 0
                return False
    return True

# Generate a full solved Sudoku board
board = [[0 for _ in range(9)] for _ in range(9)]
solve(board)
```

```
    # Remove numbers to create a puzzle
    for _ in range(random.randint(35, 50)):  # Number of cells to remove
        row, col = random.randint(0, 8), random.randint(0, 8)
        board[row][col] = 0

    return board

# Create a GUI for the Sudoku game
class SudokuGame:
    def _init_(self, root):
        self.root = root
        self.root.title("Sudoku Game")

        self.board = generate_sudoku()
        self.entries = [[None for _ in range(9)] for _ in range(9)]

        self.create_grid()
        self.create_buttons()

    def create_grid(self):
        for row in range(9):
            for col in range(9):
                entry = tk.Entry(self.root, width=5, font=('Arial', 18), justify='center')
                entry.grid(row=row, column=col, padx=5, pady=5)
                self.entries[row][col] = entry
                if self.board[row][col] != 0:
                    entry.insert(tk.END, str(self.board[row][col]))
                    entry.config(state="disabled")  # Disable pre-filled cells

    def create_buttons(self):
        check_button = tk.Button(self.root, text="Check Solution", font=('Arial', 14), command=self.check_solution)
        check_button.grid(row=9, column=0, columnspan=9)

    def check_solution(self):
        for row in range(9):
            for col in range(9):
                user_input = self.entries[row][col].get()
                if user_input:
                    if not user_input.isdigit() or int(user_input) != self.board[row][col]:
                        messagebox.showinfo("Incorrect", f"Wrong value at row {row+1}, column {col+1}")
                        return
        messagebox.showinfo("Correct", "Congratulations! Your solution is correct!")

# Initialize the Tkinter window
root = tk.Tk()
game = SudokuGame(root)
root.mainloop()
```