

Tugas Kecil 1 IF2211 Strategi Algoritma

Semester II tahun 2021/2022

Penyelesaian IQ Puzzle Pro dengan Algoritma Brute Force

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**PROGRAM STUDI TEKNIK INFORMATIKA
SEKOLAH TEKNIK ELEKTRO DAN INFORMATIKA
INSTITUT TEKNOLOGI BANDUNG 2022**

A. Algoritma Brute force

Algoritma brute force singkatnya ialah cara penyelesaian masalah dengan program yang meninjau semua kasus yang mungkin muncul berdasarkan deskripsi masalah yang diberikan.

Ada banyak approach dalam menyelesaikan suatu masalah dengan algoritma brute force, karena meskipun tujuan akhirnya sama, dalam mencapai tujuan akhir tersebut ada banyak cara yang bisa diambil. Algoritma yang saya gunakan terdiri atas beberapa tahap diantaranya Pembacaan File, Pencarian Jawaban, Serta Output.

Pembacaan File

Pada tahap pembacaan file yang ada pada class InputParser dengan nama method yaitu `parseInput` dan `getBlockObject`, Program membaca input baris demi baris lalu diubah kedalam Array of Array of character yang ada pada class Block bernama `block`.

Pencarian Jawaban

Pada tahap pencarian jawaban saya buat pada class Solver

Dua ADT utama yang dirancang penulis, yaitu ADT Block serta ADT Board. ADT Board ini digunakan untuk menyimulasikan grid karakter yang nantinya akan dipenuhi oleh block.

Struktur Data dan Spesifikasi Fungsi

```
{ Modul ADT Block }
type Block: < id: character,
             shape: array [0..MAX_SIZE-1, 0..MAX_SIZE-1] of character,
             height: integer,
             width: integer >

{ Modul ADT Board }
type Board: < N, M: integer,
             grid: array [0..MAX_N-1, 0..MAX_M-1] of character >

{ Modul ADT Solver }
type Solver: < board: Board,
             blocks: array [0..MAX_BLOCKS-1] of Block,
             nBlocks: integer,
             iterations: integer >

{ *** Konstruktor Block *** }
procedure CreateBlock(output b: Block, input id: character, input shape: array
[0..MAX_SIZE-1, 0..MAX_SIZE-1] of character)
{ I.S.: Sembarang }
{ F.S.: Block terbentuk dengan id dan shape yang diberikan }

{ *** Selektor Block *** }
function getId(b: Block) → character
function getShape(b: Block) → array [0..MAX_SIZE-1, 0..MAX_SIZE-1] of character
function getHeight(b: Block) → integer
function getWidth(b: Block) → integer

{ *** Transformasi Block *** }
function rotate(b: Block) → Block
{ Mengembalikan block yang sudah dirotasi 90 derajat searah jarum jam }

function mirror(b: Block) → Block
{ Mengembalikan block yang sudah dicerminkan secara horizontal (kanan-kiri) }
```

```

function getAllTransformations(b: Block) → array [0..7] of Block
{ Mengembalikan semua kemungkinan transformasi dari block (rotasi dan pencerminan) }

{ *** Konstruktor Board *** }
procedure CreateBoard(output b: Board, input N, M: integer)
{ I.S.: Sembarang }
{ F.S.: Board terbentuk dengan ukuran N x M, semua sel berisi '.' }

{ *** Operasi Board *** }
function canPlace(b: Board, block: Block, startX, startY: integer) → boolean
{ Mengembalikan true jika block dapat ditempatkan pada posisi (startX, startY) }

procedure placeBlock(input/output b: Board, input block: Block, input startX, startY:
integer)
{ I.S.: Board terdefinisi, posisi valid untuk menempatkan block }
{ F.S.: board Block ditempatkan pada pada posisi yang ditentukan }

procedure removeBlock(input/output b: Board, input block: Block, input startX, startY:
integer)
{ I.S.: Block sudah ada di board pada posisi yang ditentukan }
{ F.S.: Block dihapus dari board }

{ *** Konstruktor Solver *** }
procedure CreateSolver(output s: Solver, input b: Board, input blocks: array
[0..MAX_BLOCKS-1] of Block, input nBlocks: integer)
{ I.S.: Sembarang }
{ F.S.: Solver terbentuk dengan board dan blocks yang diberikan }

{ *** Solver Algorithm *** }
function solve(input/output s: Solver, input index, startX, startY: integer) → boolean
{ Mencoba menyelesaikan puzzle dengan backtracking. Mengembalikan true jika solusi
ditemukan }

```

Implementasi Fungsi Utama

```

{ Implementasi solve }
function solve(input/output s: Solver, input index: integer) → boolean
{ Fungsi rekursif untuk mencoba menempatkan blok pada setiap posisi yang valid }
KAMUS LOKAL
    block: Block
    transformations: array [0..7] of Block { maksimal 8 transformasi }
    nTransformations: integer
    row, col: integer
    transformedBlock: Block
    canSolve: boolean

ALGORITMA
    if index = s.nBlocks then
        → true { Basis: semua blok berhasil ditempatkan }

    block ← s.blocks[index]
    transformations ← getAllTransformations(block)
    nTransformations ← length(transformations)

    { Coba setiap transformasi blok }
    i traversal [0..nTransformations-1]
        transformedBlock ← transformations[i]

        { Coba setiap posisi pada papan }
        row traversal [0..s.board.N - transformedBlock.height]
            col traversal [0..s.board.M - transformedBlock.width]
                s.iterations ← s.iterations + 1

                if canPlace(s.board, transformedBlock, row, col) then
                    placeBlock(s.board, transformedBlock, row, col)
                    canSolve ← solve(s, index + 1)

    if canSolve then

```

```

→ true

removeBlock(s.board, transformedBlock, row, col) { Backtrack }

→ false { Tidak ditemukan penempatan valid untuk blok saat ini }

```

```

{ Implementasi rotate }
function rotate(b: Block) → Block
KAMUS LOKAL
    result: Block
    i, j: integer
ALGORITMA
    CreateBlock(result, b.id, [[]])
    i traversal [0..b.height-1]
        j traversal [0..b.width-1]
            result.shape[j][b.height-1-i] ← b.shape[i][j]
    result.height ← b.width
    result.width ← b.height
    → result

```

```

{ Implementasi mirror }
function mirror(b: Block) → Block
KAMUS LOKAL
    result: Block
    i, j: integer
ALGORITMA
    CreateBlock(result, b.id, [[]])
    i traversal [0..b.height-1]
        j traversal [0..b.width-1]
            result.shape[i][b.width-1-j] ← b.shape[i][j]
    result.height ← b.height
    result.width ← b.width
    → result

```

```

{ Implementasi canPlace }
function canPlace(b: Board, block: Block, startX, startY: integer) → boolean
KAMUS LOKAL
    i, j: integer
ALGORITMA
    i traversal [0..block.height-1]
        j traversal [0..block.width-1]
            if startX + i ≥ b.N or startY + j ≥ b.M or
               board[startX + i][startY + j] != '.' then
                → false
            if board[startX + i][startY + j] == '*' && block.getShape()[i][j] != '*' then
                → false {Untuk Handle Yang Custom, Jika '*' tidak bisa diisi}
    → true

```

Intuisi

Ide utama dalam menyelesaikan **IQ Puzzler Pro** adalah menggunakan **backtracking**, yaitu mencoba berbagai kemungkinan untuk setiap blok dan kembali ke langkah sebelumnya jika menemui jalan buntu.

Pada dasarnya, kita mencoba **meletakkan setiap blok satu per satu** dengan semua kemungkinan transformasi (rotasi dan pencerminan) hingga menemukan susunan yang sesuai.

Pendekatan

Kita diberikan papan IQ Puzzler Pro yang kosong dan sekumpulan blok. Pendekatan penyelesaiannya adalah sebagai berikut:

1. Menempatkan Blok:

- Kita mulai dari blok pertama dan mencoba menempatkannya di berbagai posisi pada papan.
- Setiap blok dapat **diputar dan dicerminkan**, sehingga kita harus mempertimbangkan semua kemungkinan transformasinya.

2. Memeriksa Kecocokan:

- Sebelum menempatkan blok, kita menggunakan metode `canPlace()` untuk memeriksa apakah blok tersebut bisa diletakkan di lokasi tertentu tanpa melanggar aturan.

3. Validasi Penempatan:

- Jika blok bisa ditempatkan, kita menambahkannya ke papan menggunakan `placeBlock()`.
- Algoritma kemudian melanjutkan secara **rekursif** untuk mencoba menempatkan blok berikutnya.

4. Backtracking:

- Jika menempatkan blok saat ini tidak menghasilkan solusi yang valid (rekursi mengembalikan **false**), kita akan **menghapus blok tersebut** dari papan menggunakan `removeBlock()`.
- Kemudian, kita mencoba kemungkinan posisi lainnya atau transformasi blok berikutnya.

5. Terminasi:

- Rekursi berakhir ketika semua blok berhasil ditempatkan dengan benar, yang berarti teka-teki telah terselesaikan.
- Algoritma ini memastikan bahwa solusi yang diperoleh adalah solusi valid pertama yang memenuhi kriteria, tanpa mencari solusi yang lain terlebih dahulu.

Kompleksitas

- **Kompleksitas Waktu: Eksponensial** dalam jumlah blok dan transformasinya. Sekitar $O(8^P \times N \times M)$, di mana N dan M merupakan dimensi dari papan, dan P adalah banyaknya *Piece*.
- **Kompleksitas Ruang: $O(\text{jumlah blok yang ditempatkan})$** karena kita hanya menyimpan status papan saat ini dalam rekursi.

Output

Pada tahap ini susunan board yang ditemukan akan di cetak berwarna sesuai urutan warna yang ada pada class OutputHandler di bagian static.

B. Source Code Program

1. Solver/Solver.java:

```

1  package Solver;
2
3  import java.util.List;
4
5  import DataStructure.Block;
6  import DataStructure.Board;
7
8  public class Solver {
9      private Board board;
10     private List<Block> blocks;
11     private int iterations;
12
13     public Solver(Board board, List<Block> blocks) {
14         this.board = board;
15         this.blocks = blocks;
16         this.iterations = 0;
17     }
18
19     public boolean solve(int index) {
20         if (index == blocks.size()) {
21             return true;
22         }
23
24         Block block = blocks.get(index);
25         List<Block> transformations = block.getAllTransformations();
26
27         for (Block transformedBlock : transformations) {
28             for (int row = 0; row <= board.getN() - block.getHeight(); row
29 ++) {
30                 for (int col = 0; col <= board.getM() - block.getWidth();
31 col++) {
32                     iterations++;
33                     if (board.canPlace(transformedBlock, row, col)) {
34                         board.placeBlock(transformedBlock, row, col);
35                         if (solve(index + 1)) {
36                             return true; // Solution found
37                         }
38                     }
39                 }
40             }
41             // System.out.println("Backtracking.");board.displayBoard();
42             board.removeBlock(transformedBlock, row, col);
43             // Backtrack
44         }
45         return false;
46     }
47
48     public int getIterations() {
49         return iterations;
50     }
51 }

```

2. DataStructure/Block.java:

```

package DataStructure;

import java.util.ArrayList;
import java.util.Arrays;
import java.util.List;

public class Block {
    private char id;
    private char[][] shape;

    public Block(char id, char[][] shape) {
        this.id = id;
        this.shape = shape;
        // System.out.println("Block initialized with ID: " + id);
    }

    public char getId() { return id; }
    public char[][] getShape() { return shape; }
    public int getHeight() { return shape.length; }
    public int getWidth() { return shape[0].length; }

    public Block rotate() {
        // System.out.println("Rotating block " + id);
        int rows = shape.length, cols = shape[0].length;
        char[][] rotated = new char[cols][rows];
        for (int i = 0; i < rows; i++)
            for (int j = 0; j < cols; j++)
                rotated[j][rows - 1 - i] = shape[i][j];
        return new Block(id, rotated);
    }

    public Block mirror() {
        // System.out.println("Mirroring block " + id);
        int rows = shape.length, cols = shape[0].length;
        char[][] mirrored = new char[rows][cols];
        for (int i = 0; i < rows; i++)
            for (int j = 0; j < cols; j++)
                mirrored[i][cols - 1 - j] = shape[i][j];
        return new Block(id, mirrored);
    }

    public void displayBlock() {
        // System.out.println("Displaying block " + id);
        for (char[] row : shape) {
            for (char cell : row) {
                System.out.print(cell + " ");
            }
            System.out.println();
        }
    }

    public List<Block> getAllTransformations() {
        List<Block> transformations = new ArrayList<>();
        Block current = this;
        for (int i = 0; i < 4; i++) {
            transformations.add(current);
            Block mirrored = current.mirror();
            transformations.add(mirrored);
            current = current.rotate();
        }
        return transformations;
    }

    @Override
    public String toString() {
        StringBuilder sb = new StringBuilder();
        sb.append("Block{");
        sb.append("id=").append(id).append(", ");
        sb.append("shape=");
        for (char[] row : shape) {
            sb.append(Arrays.toString(row)).append(", ");
        }
        sb.delete(sb.length() - 2, sb.length()); // hapus koma terakhir
        sb.append("}");
        return sb.toString();
    }
}

```


3. DataStructure/Board.java:

```
1 package DataStructure;
2 // package Board;
3 import java.util.*;
4
5 public class Board {
6     private int N, M;
7     private char[][] board;
8
9     public Board(int N, int M) {
10         this.N = N;
11         this.M = M;
12         this.board = new char[N][M];
13         for (char[] row : board) {
14             Arrays.fill(row, '.');
15         }
16     }
17     public char getCell(int i, int j) {
18         return board[i][j];
19     }
20     public int getN() { return this.N; }
21     public int getM() { return this.M; }
22
23     public void setCell(int i, int j, char c) {
24         board[i][j] = c;
25     }
26     public boolean isOutOfBounds(int x, int y) {
27         if (x < 0 || y < 0 || x >= N || y >= M) {
28             return true;
29         }
30         return false;
31     }
32
33     public boolean canPlace(Block block, int startX, int startY) {
34         try {
35             for (int i = 0; i < block.getHeight(); i++) {
36                 for (int j = 0; j < block.getWidth(); j++) {
37                     if (block.getShape()[i][j] != '.') {
38                         if (startX + i >= N || startY + j >= M || board[
39 startX + i][startY + j] != '.') {
40                             return false;
41                         }
42                         if (board[startX + i][startY + j] == '*' && block.
43 getShape()[i][j] != '*') {
44                             System.out.println("
45 Error: Cannot place block on '*' cell.");
46                             return false;
47                         }
48                     }
49                 }
50             }
51         } catch (ArrayIndexOutOfBoundsException e) {
52             return false;
53         }
54         return true;
55     }
56
57     public void placeBlock(Block block, int startX, int startY) {
58         for (int i = 0; i < block.getHeight(); i++) {
59             for (int j = 0; j < block.getWidth(); j++) {
60                 if (block.getShape()[i][j] != '.') {
61                     board[startX + i][startY + j] = block.getId();
62                 }
63             }
64         }
65     }
66
67     public void removeBlock(Block block, int startX, int startY) {
68         for (int i = 0; i < block.getHeight(); i++) {
69             for (int j = 0; j < block.getWidth(); j++) {
70                 if (block.getShape()[i][j] != '.') {
71                     board[startX + i][startY + j] = '.';
72                 }
73             }
74         }
75     }
76
77     public void displayBoard() {
78         for (char[] row : board) {
79             for (char cell : row) {
80                 System.out.print(cell + " ");
81             }
82             System.out.println();
83         }
84     }
85
86     public void setGrid(char[][] grid) {
87         this.board = grid;
88     }
89 }
```

4. IO/InputParser.java:

```
1 public class InputParser {
2     private int N, M, P;
3     private String caseType;
4     ;
5     private List<List<
6     String>> blocks;
7     private Board board;
8
9     public InputParser() {
10         blocks = new
11         ArrayList<>();
12         board = new Board(N
13         , M);
14     }
```

```
1 private char getFirstValidChar(String str) {
2     for (char c : str.toCharArray()) {
3         if (c != ' ' && c != '\n' && c != '\r' && c != '\0') {
4             return c;
5         }
6     }
7     throw new RuntimeException("Tidak dapat menemukan karakter blok yang valid.");
8 }
9
10 public int getN() { return N; }
11 public int getM() { return M; }
12 public int getP() { return P; }
13 public String getCaseType() { return caseType; }
14 public List<List<String>> getBlocks() { return blocks; }
15
16 public Board getBoard() {
17     return board;
18 }
```

```

1 public void parseInput(String filePath) throws IOException {
2     BufferedReader br = new BufferedReader(new FileReader(filePath));
3     String[] dimensions = br.readLine().split(" ");
4     if (dimensions.length < 3) {
5         br.close();
6         throw new IllegalArgumentException("
7     Error: Dimensi papan tidak ditemukan dalam file atau tidak lengkap.");
8     }
9     try {
10         N = Integer.parseInt(dimensions[0]);
11         M = Integer.parseInt(dimensions[1]);
12         P = Integer.parseInt(dimensions[2]);
13     } catch (NumberFormatException e) {
14         br.close();
15         throw new IllegalArgumentException("
16     Error: Nilai N, M, atau P tidak ditemukan dalam file atau bukan bilangan bulat.");
17     }
18     if (P > 26) {
19         br.close();
20         throw new IllegalArgumentException("Error: Jumlah blok (" + P + "
21     ) melebihi batas maksimum (26).");
22     }
23     caseType = br.readLine().replace("\r", "").replace("\0", "");
24     if (!caseType.equals("DEFAULT") && !caseType.equals("CUSTOM")) {
25         br.close();
26         throw new IllegalArgumentException("Error: Case type tidak valid.");
27     }
28     Board board = new Board(N, M);
29     if (caseType.equals("CUSTOM")) {
30         char[][] initialGrid = new char[N][M];
31         for (int i = 0; i < N; i++) {
32             String line = br.readLine().replace("\r", "").replace("\0", "");
33             for (int j = 0; j < M; j++) {
34                 initialGrid[i][j] = (line.charAt(j) == '.' ? '*' : '.');
35             }
36         }
37         board.setGrid(initialGrid);
38     }
39     this.board = board;
40
41     List<String> lines = new ArrayList<>();
42     String line;
43     while ((line = br.readLine()) != null) {
44         line = line.replace("\r", "").replace("\0", "");
45         if (!line.isEmpty()) {
46             lines.add(line);
47         }
48     }
49     br.close();
50
51     if (lines.isEmpty()) {
52         throw new IOException("Error: Tidak ada data blok dalam file.");
53     }
54
55     char currentBlockId = getFirstValidChar(lines.get(0));
56     List<String> currentBlock = new ArrayList<>();
57
58     for (String l : lines) {
59         l = l.replace("\r", "").replace("\0", "");
60         if (l.isEmpty()) continue;
61
62         for (int i = 0; i < l.length(); i++) {
63             if (l.charAt(i) != currentBlockId && l.charAt(i) != ' ') {
64                 if (!currentBlock.isEmpty()) {
65                     blocks.add(new ArrayList<>(currentBlock));
66                     currentBlock.clear();
67                 }
68                 currentBlockId = l.charAt(i);
69             }
70         }
71         currentBlock.add(l);
72     }
73     if (!currentBlock.isEmpty()) {
74         blocks.add(currentBlock);
75     }
76     if (blocks.size() != P) {
77         throw new IOException("Jumlah blok yang terbaca tidak sesuai dengan P");
78     }
79 }

```

```

1 public List<Block> getBlockObjects() {
2     List<Block> blockObjects = new ArrayList<>();
3     for (List<String> blockShape : blocks) {
4         int height = blockShape.size();
5         int max_width = blockShape.stream().mapToInt(String::length).max().orElse(0);
6         char[][] shape = new char[height][max_width];
7         char blockId = getBlockId(blockShape);
8
9         for (int i = 0; i < height; i++) {
10             for (int j = 0; j < max_width; j++) {
11                 if (j < blockShape.get(i).length() && blockShape.get(i).charAt(j) ==
12 ' ') {
13                     shape[i][j] = '.';
14                 }
15                 else if (j < blockShape.get(i).length() && blockShape.get(i).charAt(j)
16 ) == blockId) {
17                     shape[i][j] = blockShape.get(i).charAt(j);
18                 } else {
19                     shape[i][j] = '.';
20                 }
21             }
22             blockObjects.add(new Block(blockId, shape));
23         }
24         return blockObjects;
25     }
26
27     private char getBlockId(List<String> blockShape) {
28         for (String row : blockShape) {
29             for (char c : row.toCharArray()) {
30                 if (c != ' ' && c != '.') {
31                     return c;
32                 }
33             }
34         }
35         throw new RuntimeException("Tidak dapat menemukan karakter blok");
36     }

```

5. IO/OutputHandler.java:

```
public class OutputHandler {
    // ANSI color codes for terminal output
    private static final String RESET = "\u001B[0m";
    private static final Map<Character, String> BLOCK_COLORS = new HashMap<>();
    private static final Map<Character, Color> IMAGE_COLORS = new HashMap<>();
    private static final int CELL_SIZE = 50; // Size of each cell in pixel

    static {
        BLOCK_COLORS.put('A', "\u001B[31m");
        BLOCK_COLORS.put('B', "\u001B[34m");
        BLOCK_COLORS.put('C', "\u001B[32m");
        BLOCK_COLORS.put('D', "\u001B[35m");
        BLOCK_COLORS.put('E', "\u001B[33m");
        BLOCK_COLORS.put('F', "\u001B[36m");
        BLOCK_COLORS.put('G', "\u001B[35m");
        BLOCK_COLORS.put('H', "\u001B[94m");
        BLOCK_COLORS.put('I', "\u001B[92m");
        BLOCK_COLORS.put('J', "\u001B[93m");
        BLOCK_COLORS.put('K', "\u001B[91m");
        BLOCK_COLORS.put('L', "\u001B[96m");
        BLOCK_COLORS.put('M', "\u001B[90m");
        BLOCK_COLORS.put('N', "\u001B[97m");
        BLOCK_COLORS.put('O', "\u001B[37m");
        BLOCK_COLORS.put('P', "\u001B[30m");
        BLOCK_COLORS.put('Q', "\u001B[38;5;208 ");
        BLOCK_COLORS.put('R', "\u001B[38;5;202 ");
        BLOCK_COLORS.put('S', "\u001B[38;5;120 ");
        BLOCK_COLORS.put('T', "\u001B[38;5;93m");
        BLOCK_COLORS.put('U', "\u001B[38;5;27m");
        BLOCK_COLORS.put('V', "\u001B[38;5;28m");
        BLOCK_COLORS.put('W', "\u001B[38;5;226 ");
        BLOCK_COLORS.put('X', "\u001B[38;5;87m");
        BLOCK_COLORS.put('Y', "\u001B[38;5;141 ");
        BLOCK_COLORS.put('Z', "\u001B[38;5;203 ");

        IMAGE_COLORS.put('A', new Color(255, 0, 0));
        IMAGE_COLORS.put('B', new Color(0, 0, 255));
        IMAGE_COLORS.put('C', new Color(0, 255, 0));
        IMAGE_COLORS.put('D', new Color(128, 0, 128));
        IMAGE_COLORS.put('E', new Color(255, 255, 0));
        IMAGE_COLORS.put('F', new Color(0, 255, 255));
        IMAGE_COLORS.put('G', new Color(255, 192, 203));
        IMAGE_COLORS.put('H', new Color(173, 216, 230));
        IMAGE_COLORS.put('I', new Color(144, 238, 144));
        IMAGE_COLORS.put('J', new Color(255, 228, 181));
        IMAGE_COLORS.put('K', new Color(220, 20, 60));
        IMAGE_COLORS.put('L', new Color(70, 130, 180));
        IMAGE_COLORS.put('M', new Color(47, 79, 79));
        IMAGE_COLORS.put('N', new Color(245, 245, 245));
        IMAGE_COLORS.put('O', new Color(169, 169, 169));
        IMAGE_COLORS.put('P', new Color(0, 0, 0));
        IMAGE_COLORS.put('Q', new Color(255, 140, 0));
        IMAGE_COLORS.put('R', new Color(255, 69, 0));
        IMAGE_COLORS.put('S', new Color(255, 105, 180));
        IMAGE_COLORS.put('T', new Color(148, 0, 211));
        IMAGE_COLORS.put('U', new Color(25, 25, 112));
        IMAGE_COLORS.put('V', new Color(34, 139, 34));
        IMAGE_COLORS.put('W', new Color(255, 255, 102));
        IMAGE_COLORS.put('X', new Color(0, 206, 209));
        IMAGE_COLORS.put('Y', new Color(216, 191, 216));
        IMAGE_COLORS.put('Z', new Color(250, 128, 114));
    }

    public static void displayColoredBoard (Board board) {
        for (int i = 0; i < board.getM(); i++) {
            for (int j = 0; j < board.getN(); j++) {
                char cell = board.getCell(i, j);
                if (cell != '.') {
                    System.out.print(BLOCK_COLORS.getOrDefault(cell, RESET) + cell + " " + RESET);
                } else {
                    System.out.print(cell + " ");
                }
            }
            System.out.println();
        }
    }
}
```

```

public static void saveBoardAsImage(Board board, String filePath, long time, long cases) throws
IOException {
    int width = board.getM() * CELL_SIZE;
    int height = board.getN() * CELL_SIZE + 100;

    BufferedImage image = new BufferedImage(width, height, BufferedImage.TYPE_INT_RGB);
    Graphics2D g2d = image.createGraphics();

    g2d.setColor(Color.WHITE);
    g2d.fillRect(0, 0, width, height);

    for (int i = 0; i < board.getN(); i++) {
        for (int j = 0; j < board.getM(); j++) {
            char cell = board.getCell(i, j);
            if (cell != '.') {
                g2d.setColor(IMAGE_COLORS.getOrDefault(cell, Color.GRAY));
                g2d.fillRect(j * CELL_SIZE, i * CELL_SIZE, CELL_SIZE, CELL_SIZE);
            }

            g2d.setColor(Color.BLACK);
            g2d.drawRect(j * CELL_SIZE, i * CELL_SIZE, CELL_SIZE, CELL_SIZE);
        }
    }

    g2d.setFont(new Font("Arial", Font.BOLD, CELL_SIZE/2));
    for (int i = 0; i < board.getN(); i++) {
        for (int j = 0; j < board.getM(); j++) {
            char cell = board.getCell(i, j);
            if (cell != '.') {
                g2d.setColor(Color.BLACK);
                String label = String.valueOf(cell);
                FontMetrics metrics = g2d.getFontMetrics();
                int x = j * CELL_SIZE + (CELL_SIZE - metrics.stringWidth(label)) / 2;
                int y = i * CELL_SIZE + ((CELL_SIZE + metrics.getHeight()) / 2) - metrics.getDescent();
                g2d.drawString(label, x, y);
            }
        }
    }

    g2d.setFont(new Font("Arial", Font.BOLD, 24));
    g2d.setColor(Color.BLACK);
    String timeLabel = "Time: " + time + " ms";
    String iterationsLabel = "Iterations: " + cases;
    g2d.drawString(timeLabel, 10, board.getN() * CELL_SIZE + 30);
    g2d.drawString(iterationsLabel, 10, board.getN() * CELL_SIZE + 60);

    g2d.dispose();

    File outputFile = new File(filePath);
    ImageIO.write(image, "png", outputFile);
    System.out.println("Image saved to " + filePath);
}

```


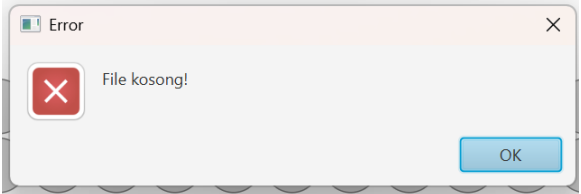
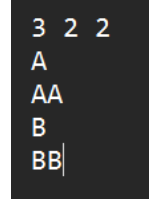
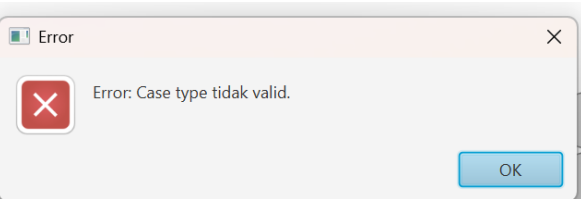
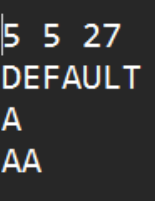
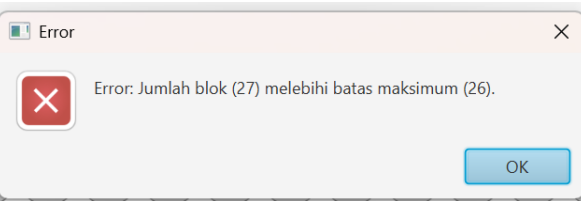
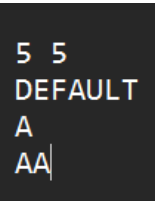
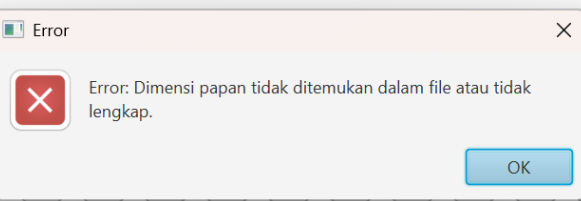
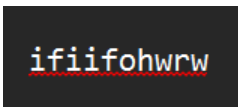
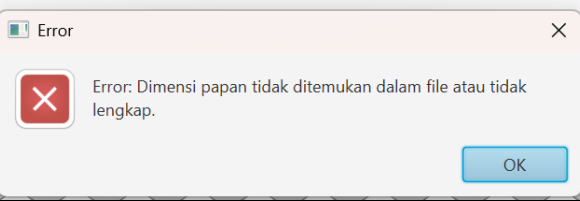
```

1 public static void saveBoardAsText(Board board, String filePath, long time, long cases)
  throws IOException {
2     try (FileWriter writer = new FileWriter(filePath)) {
3         for (int i = 0; i < board.getN(); i++) {
4             for (int j = 0; j < board.getM(); j++) {
5                 char cell = board.getCell(i, j);
6                 writer.write(cell + " ");
7             }
8             writer.write("\n");
9         }
10        writer.write("Time execution: " + time + " ms\n");
11        writer.write("Iterations: " + cases + "\n\n");
12    }
13    System.out.println("Text file saved to " + filePath);
14 }
15 }

```

C. Testing

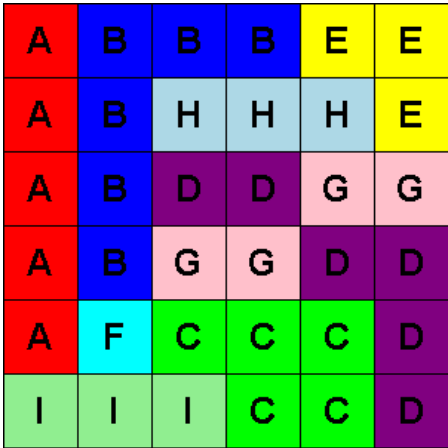
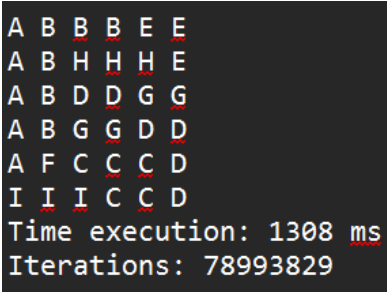
Testcase Input validasi:

Nama Testcase	Input	Output
Testcase-1 (File kosong)		
Testcase-2 (File tidak memiliki CaseType)		
Testcase-3 (P > 26):		
Testcase-4 (P Tidak ada)		
Testcase-5		

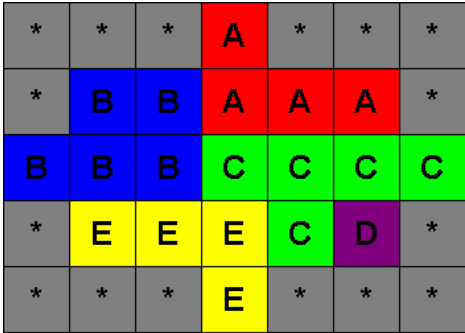
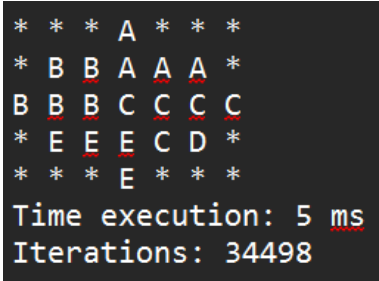
Testcase Tambahan:

Testcase-6:

Input	Hasil Gambar	Hasil txt
-------	--------------	-----------

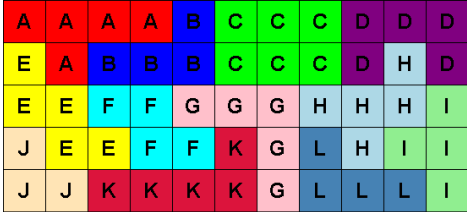
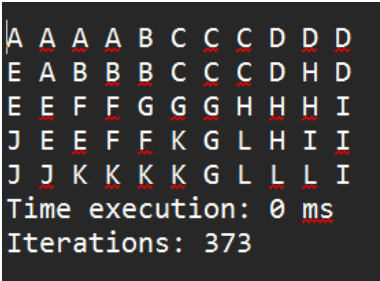
6 6 9 DEFAULT A A A A A A BBB B B B CCC CC D D DD DD E EE F GG GG HHH III	 <p>Time: 1308 ms Iterations: 78993829</p>	
---	---	--

Testcase-7 (Konfigurasi Custom):

Input	Hasil Gambar	Hasil txt
5 7 5 CUSTOM ...X... .XXXXX. XXXXXXXX .XXXXX. ...X... A AAA BB BBB CCCC C D EEE E	 <p>Time: 5 ms Iterations: 34498</p>	

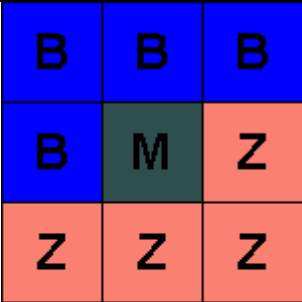
Testcase ke-8:

Input	Hasil Gambar	Hasil txt
-------	--------------	-----------

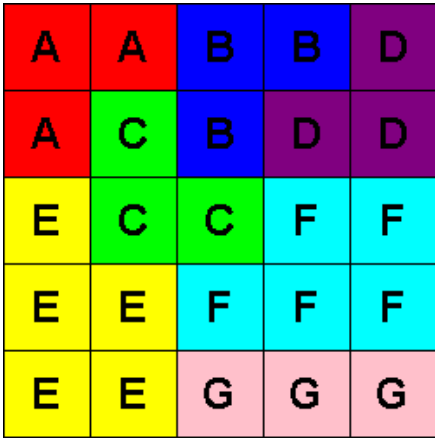
5 11 12 DEFAULT AAAA A B BBB CCC CCC DDD D D E EE EE FF FF GGG G G H HHH H I II I J JJ KKKK K L LLL	 <p>Time: 0 ms Iterations: 373</p>	 <p>Time execution: 0 ms Iterations: 373</p>
--	---	--

Testcase-9 (Tidak Urut):

Input	Hasil Gambar	Hasil txt
-------	--------------	-----------

<pre> 3 3 3 DEFAULT BBB B M Z ZZZ </pre>	 <p>Time: 16 ms Iterations: 8</p>	<pre> B B B B M Z Z Z Z Time execution: 15 ms Iterations: 8 </pre>
--	--	--

Testcase-10:

Input	Hasil Gambar	Hasil txt
<pre> 5 5 7 DEFAULT AA A BB B C CC D DD EE EE E FF FF F GGG </pre>	 <p>Time: 1 ms Iterations: 8489</p>	<pre> A A B B D A C B D D E C C F F E E F F F E E G G G Time execution: 1 ms Iterations: 8489 </pre>

D. Extra

Alamat Github : https://github.com/Farhanabd05/Tucil1_13523042

Spek Laptop (soalnya beda spek laptop, beda runtime) :

- Windows 11
- RAM 12 GB
- Intel Core i5
- SSD 512 GB

Checklist :

No	Poin	Ya	Tidak
1	Program berhasil dikompilasi tanpa kesalahan	✓	
2	Program berhasil dijalankan	✓	
3	Solusi yang diberikan program benar dan mematuhi aturan permainan	✓	
4	Program dapat membaca masukan berkas .txt serta menyimpan solusi dalam berkas .txt	✓	
5	Program memiliki Graphical User Interface (GUI)	✓	
6	Program dapat menyimpan solusi dalam bentuk file gambar	✓	
7	Program dapat menyelesaikan kasus konfigurasi custom	✓	
8	Program dapat menyelesaikan kasus konfigurasi Piramida (3D)		✓
9	Program dibuat oleh saya sendiri	✓	