LAPORAN TUGAS KECIL

IF2211/Strategi Algoritma

Penyelesaian Persoalan 15-Puzzle dengan Algoritma Branch and Bound

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A. Cara Kerja program Branch and Bound

Puzzle yang ingin di solve diperlakukan sebagai matrix, mula-mula dihitung sigma kurang + X dari puzzle untuk mengecek apakah puzzle solveable, jika hasilnya negatif maka puzzle tidak solveable dan sebaliknya. Jika puzzle solveable, puzzle sebagai node parent, kemudian dibuat 4 child yang merupakan turunan dari parent. Setiap node dihitung costnya dengan cara menambahkan kedalaman simpul dari akar dan estimasi cost untuk ke final. simpul-simpul tersebut kemudian dimasukkan ke priority queue dengan sistem mengurut membesar. Simpul dengan cost terkecil dipilih sebagai parent node lokal, yang kemudian akan men-generate child node, begitu seterusnya sampai didapat puzzle final.

B. Screenshoot Input-Output Program

1. Puzzle1.txt

```
Masukkan nama file: puzzle1.txt
Kurang(1) = 0
Kurang(2) = 1
Kurang(3) = 1
Kurang(4) = 1
Kurang(5) = 0
Kurang(6) = 1
Kurang(7) = 2
Kurang(8) = 1
Kurang(9) = 3
Kurang(10) = 6
Kurang(11) = 2
Kurang(12) = 0
Kurang(13) = 3
Kurang(14) = 1
Kurang(15) = 4
Kurang(16) = 2
SigmaKurang(i): 28
2  3  4  10
1  7  9  6
11 13 15 8
5  16  14 12

2  3  4  10
1  7  9  6
11 16  15 8
5  13 14 12

2  3  4  10
1  7  9  6
16  11 15 8
5  13 14 12

2  3  4  10
1  7  9  6
5  11 15 8
16  13 14 12

2  3  4  10
1  7  9  6
5  11 15 8
13 16  14 12

2  3  4  10
1  7  9  6
5  11 15 8
13 14 16  12
```

```
2  3  4  10
1  7  9  6
5  11 16  8
13 14 15 12

2  3  4  10
1  7  9  6
5  16  11 8
13 14 15 12

2  3  4  10
1  16  9  6
5  7  11 8
13 14 15 12

2  3  4  10
1  9  16  6
5  7  11 8
13 14 15 12

2  3  4  10
1  9  6  16
5  7  11 8
13 14 15 12

2  3  4  16
1  9  6  10
5  7  11 8
13 14 15 12

2  3  16  4
1  9  6  10
5  7  11 8
13 14 15 12

2  3  6  4
1  9  16  10
5  7  11 8
13 14 15 12

2  3  6  4
1  9  10 16
5  7  11 8
13 14 15 12

2  3  6  4
1  9  10 8
5  7  11 16
13 14 15 12

2  3  6  4
1  9  10 8
5  7  16  11
13 14 15 12
```

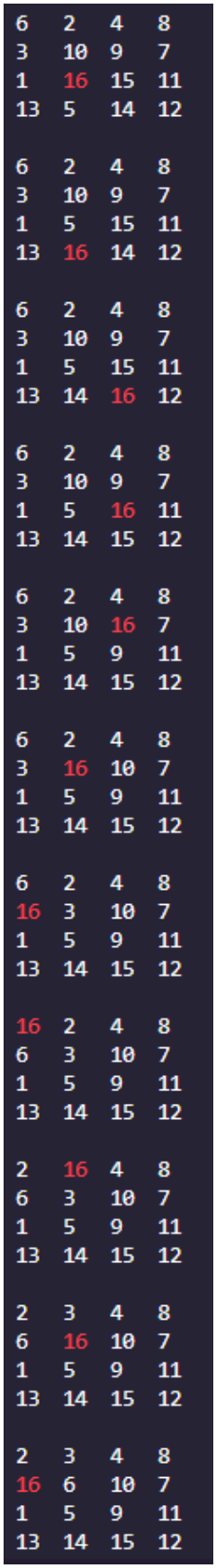
```
2  3  6  4
1  9  10 8
5  16  7  11
13 14 15 12

2  3  6  4
1  16  10 8
5  9  7  11
13 14 15 12

2  3  6  4
1  10 16  8
5  9  7  11
13 14 15 12

2  3  16  4
1  10 6  8
5  9  7  11
5  10 6  8
9  16  7  11
13 14 15 12

1  2  3  4
5  16  6  8
9  10 7  11
13 14 15 12

1  2  3  4
5  6  16  8
9  10 7  11
13 14 15 12

1  2  3  4
5  6  7  8
9  10 16  11
13 14 15 12

1  2  3  4
5  6  7  8
9  10 11 16
13 14 15 12

1  2  3  4
5  6  7  8
9  10 11 12
13 14 15 16

Banyak anak dibangkitkan: 1846802
Execution time:  77.24075746536255
```

2. Puzzle2.txt

```
Masukkan nama file: puzzle2.txt
Kurang(1) = 0
Kurang(2) = 0
Kurang(3) = 1
Kurang(4) = 1
Kurang(5) = 0
Kurang(6) = 0
Kurang(7) = 1
Kurang(8) = 0
Kurang(9) = 0
Kurang(10) = 0
Kurang(11) = 3
Kurang(12) = 6
Kurang(13) = 0
Kurang(14) = 4
Kurang(15) = 11
Kurang(16) = 10
SigmaKurang(i): 37
puzzle tidak solveable
```

3. Puzzle3.txt

```
Masukkan nama file: puzzle3.txt
Kurang(1) = 0
Kurang(2) = 1
Kurang(3) = 1
Kurang(4) = 2
Kurang(5) = 0
Kurang(6) = 5
Kurang(7) = 2
Kurang(8) = 4
Kurang(9) = 3
Kurang(10) = 4
Kurang(11) = 0
Kurang(12) = 1
Kurang(13) = 3
Kurang(14) = 4
Kurang(15) = 5
Kurang(16) = 4
SigmaKurang(i): 40
6   2   4   8
3   10  9   7
1   15  14  16
13  5   12  11

6   2   4   8
3   10  9   7
1   15  14  11
13  5   12  16

6   2   4   8
3   10  9   7
1   15  14  11
13  5   16  12

6   2   4   8
3   10  9   7
1   15  16  11
13  5   14  12
```

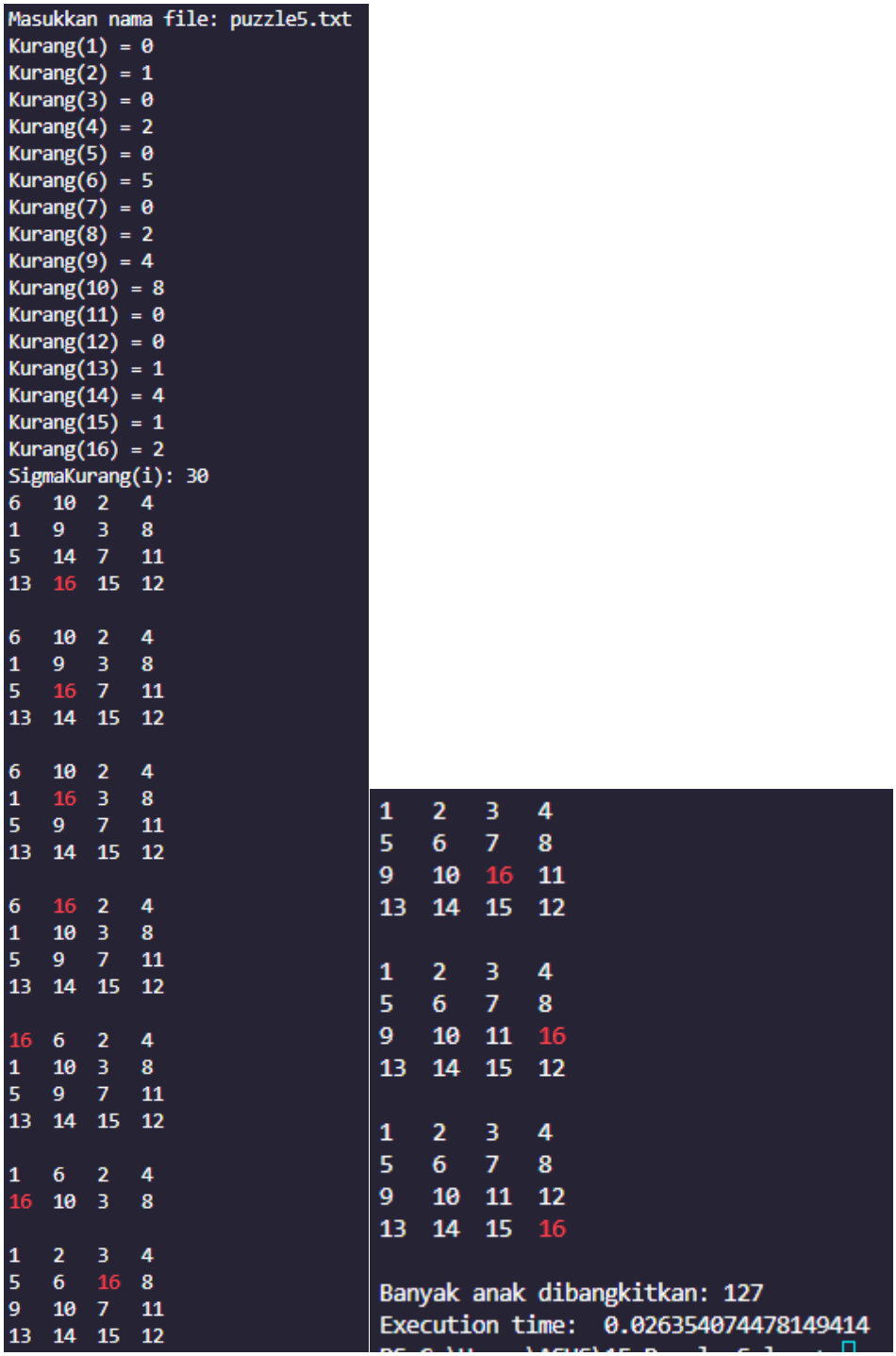

6 2 4 8
3 10 9 7
1 16 15 11
13 5 14 12
6 2 4 8
3 10 9 7
1 5 15 11
13 16 14 12
6 2 4 8
3 10 9 7
1 5 15 11
13 14 16 12
6 2 4 8
3 10 9 7
1 5 16 11
13 14 15 12
6 2 4 8
3 10 16 7
1 5 9 11
13 14 15 12
6 2 4 8
3 16 10 7
1 5 9 11
13 14 15 12
6 2 4 8
16 3 10 7
1 5 9 11
13 14 15 12
16 2 4 8
6 3 10 7
1 5 9 11
13 14 15 12
2 16 4 8
6 3 10 7
1 5 9 11
13 14 15 12
2 3 4 8
6 16 10 7
1 5 9 11
13 14 15 12
2 3 4 8
16 6 10 7
1 5 9 11
13 14 15 12

```
2   3   4   16
1   6   7   8
5   9   10  11
13  14  15  12

2   3   16  4
1   6   7   8
5   9   10  11
13  14  15  12

2   16  3   4
1   6   7   8
5   9   10  11
13  14  15  12

1   2   3   4
5   6   7   8
9   16  10  11
13  14  15  12

1   2   3   4
5   6   7   8
9   10  16  11
13  14  15  12

1   2   3   4
5   6   7   8
9   10  11  16
13  14  15  12

1   2   3   4
5   6   7   8
9   10  11  12
13  14  15  16

Banyak anak dibangkitkan: 1592846
Execution time:  53.68953609466553
```

4. Puzzle4.txt

```
Masukkan nama file: puzzle4.txt
Kurang(1) = 0
Kurang(2) = 0
Kurang(3) = 0
Kurang(4) = 2
Kurang(5) = 4
Kurang(6) = 2
Kurang(7) = 5
Kurang(8) = 2
Kurang(9) = 0
Kurang(10) = 4
Kurang(11) = 3
Kurang(12) = 2
Kurang(13) = 2
Kurang(14) = 3
Kurang(15) = 5
Kurang(16) = 1
SigmaKurang(i): 37
puzzle tidak solveable
```

5. Puzzle5.txt



C. Source Code

1. preprogress.py

```
#mengisi matrix puzzle dengan inputan user
def getPuzzle():
    puzzle = [list(map(int,input().split())) for i in range(4)]
    return puzzle

#16 = ubin kosong

#menghitung nilai fungsi kurang(i) dari ubin i
def kurang(puzzle,i,j ):
    count = 0
    ubin = i*4 + j+1
    for u in range(4):
        for v in range(4):
            ubin2 = u*4 + v+1
            if(puzzle[u][v] < puzzle[i][j] and ubin2>ubin):
                count+=1
    return count

def printKurang(puzzle):
    array = [0 for i in range(17)]
    for p in range(4):
        for q in range(4):
            array[puzzle[p][q]] = kurang(puzzle,p,q)
    for i in range(1,17):
        print("Kurang("+ str(i)+ ") =", array[i])

#hitung kurang(i)+X
def isReachableGoal(puzzle):
    sum = 0
    X = -1
    for i in range(4):
        for j in range(4):
            if (puzzle[i][j] == 16):
                X = (i+j)%2
            sum += kurang(puzzle,i,j)
    if (X != -1):
        sum += X
        return sum
    else:
        return -1

#mendapatkan tile yang kosong
def emptyTile(puzzle):
```

```
    for i in range(4):
        for j in range(4):
            if(puzzle[i][j] == 16):
                return [i,j]

```

2. Solver.py

```
from asyncio.windows_events import NULL
import copy
from heapq import heappush, heappop

#Class priorityqueue
class priorityQueue:
    def __init__(self):
        self.heap = []

    def push(self, k):
        heappush(self.heap, k)

    def pop(self):
        return heappop(self.heap)

    def isEmpty(self):
        if not self.heap:
            return True
        else:
            return False
#class node
class node:

    def __init__(self, parent,puz, empty_tile_pos,
                 cost, level,direction):

        self.parent = parent

        self.puz = puz

        self.empty_tile_pos = empty_tile_pos

        self.cost = cost

        self.level = level

        self.direction = direction
```

```
    def __lt__(self, nxt):
        return self.cost < nxt.cost

#menghitung cost simpul
def calculateCost(puz, final,level) -> int:

    count = level
    for i in range(4):
        for j in range(4):
            if (puz[i][j] and puz[i][j] != final[i][j]):
                count += 1

    return count

#membuat node baru
def newNode(mat, empty_tile_pos, new_empty_tile_pos,
            level, parent, final,direction) -> node:

    new_mat = copy.deepcopy(mat)

    x1 = empty_tile_pos[0]
    y1 = empty_tile_pos[1]
    x2 = new_empty_tile_pos[0]
    y2 = new_empty_tile_pos[1]
    new_mat[x1][y1], new_mat[x2][y2] = new_mat[x2][y2], new_mat[x1][y1]

    cost = calculateCost(new_mat, final,level)

    new_node = node(parent, new_mat, new_empty_tile_pos,
                    cost, level,direction)
    return new_node

#mencetak jawaban dari akar ke daun
def printTree(root):

    if root == None:
        return

    printTree(root.parent)
    printMatrix(root.puz)
    print()

#print matrix
def printMatrix(mat):
```

```
    for i in range(4):
        for j in range(4):
            if(mat[i][j] == 16):
                print("\033[91m{}\033[00m".format(str(mat[i][j])), end = "  ")
            elif(mat[i][j] < 10):
                print(mat[i][j], end = "  ")
            else:
                print(mat[i][j], end = " ")


        print()


def isValid(x, y):
    return x >= 0 and x < 4 and y >= 0 and y < 4

#empty slot baru
def new_empty(empty_tile,dir):
    new = [-1,-1]
    if (dir == "left"):
        new[0] = empty_tile[0]
        new[1] = empty_tile[1]-1
    elif(dir == "right"):
        new[0] = empty_tile[0]
        new[1] = empty_tile[1]+1
    elif(dir == "up"):
        new[0] = empty_tile[0]-1
        new[1] = empty_tile[1]
    elif(dir == "down"):
        new[0] = empty_tile[0]+1
        new[1] = empty_tile[1]
    return new

#memeriksa apakah puzzle = final
def isEqual(puzzle,final):
    for i in range(4):
        for j in range(4):
            if(puzzle[i][j] != final[i][j]):
                return False
    return True

def solve(initial, empty_tile_pos, final):
    count = 0

    pq = priorityQueue()
```

```
    cost = calculateCost(initial, final,0)
    root = node(None, initial,
                empty_tile_pos, cost, 0, NULL)
    pq.push(root)
    while not pq.isEmpty():

        minimum = pq.pop()
        #memeriksa apakah sudah sesuai dengan final
        if isEqual(minimum.puz,final):
            printTree(minimum)
            print("Banyak anak dibangkitkan:" , count)
            return

        #menentukan arah direction baru agar tidak looping
        if minimum.direction == NULL:
            directions = ["left","right","up","down"]
        elif minimum.direction == "left":
            directions = ["left","up","down"]
        elif minimum.direction == "right":
            directions = ["right","up","down"]
        elif minimum.direction == "up":
            directions = ["left","right","up"]
        elif minimum.direction == "down":
            directions = ["left","right","down"]

        for i in range(len(directions)):
            new_tile_pos = new_empty(minimum.empty_tile_pos,directions[i])

            if isValid(new_tile_pos[0], new_tile_pos[1]):

                #buat node baru
                new_node = newNode(minimum.puz,
                                   minimum.empty_tile_pos,
                                   new_tile_pos,
                                   minimum.level + 1,
                                   minimum, final, directions[i])
                #masukkan node baru ke prioqueue
                pq.push(new_node)
                count += 1
```

3. main.py

```
import sys
```

```
#change with ur path
sys.path.insert(0, 'C:/Users/ASUS/15-Puzzle-Solver/src')
import os
import time
import preprogress
import Solver

final = [[1,2,3,4],[5,6,7,8],[9,10,11,12],[13,14,15,16]]

os.chdir("./TestCase")
file = input("Masukkan nama file: ")

f = open(file,"r")


puzzle = []
for item in f:
    arr = (item.strip("\n").split(" ")[:4])
    arr2 = []
    for i in arr:
        idx = int(i)
        arr2.append(idx)
    puzzle.append(arr2)
f.close()

#print kurang(i)
preprogress.printKurang(puzzle)

#print sigmakurang
sigmakurang = preprogress.isReachableGoal(puzzle)
print("SigmaKurang(i):",sigmakurang)

#is reachable goal?
if(sigmakurang%2 == 1):
    print("puzzle tidak solveable")
else:
    start = time.time()
    Solver.solve(puzzle,preprogress.emptyTile(puzzle),final)
    end = time.time()
    print("Execution time: ",end-start)
```

D. Berkas Text Puzzle

1. Puzzle1.txt

   2 3 4 10
   1 7 9 6
   11 13 15 8

5 16 14 12

2. Puzzle2.txt
   1 3 4 15
   2 16 5 12
   7 6 11 14
   8 9 10 13

3. Puzzle3.txt
   6 2 4 8
   3 10 9 7
   1 15 14 16
   13 5 12 11

4. Puzzle4.txt
   5 7 2 4
   6 10 8 11
   1 15 12 14
   13 2 16 9

5. Puzzle5.txt
   6 10 2 4
   1 9 3 8
   5 14 7 11
   13 16 15 12

E. Checklist

Poin	Ya	Tidak
1. Program berhasil dikompilasi	v	
2. Program berhasil running	v	
3. Program dapat menerima input dan menuliskan output	v	
4.Luaran sudah benar untuk semua data uji	v	
5. Bonus dibuat		v

Github : https://github.com/VionieNovencia/15-Puzzle-Solver.git