

Tugas Kecil 1 IF2211 Strategi Algoritma:

Implementasi Penyelesaian Puzzle-15 dengan Algoritma Branch & Bounce



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PROGRAM STUDI TEKNIK INFORMATIKA
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DAFTAR ISI

- A. Algoritma Penyelesaian Puzzle-15 3
- B. Source Code 4
 - 1. Board.py 4
 - 2. Other.py 5
 - 3. Main.py 6
- C. CONTOH EKSEKUSI PROGRAM..... 7
 - 1. Dataset 1 (test/in1.txt)..... 7
 - 2. Dataset 2 (test/in2.txt)..... 8
 - 3. Dataset 3 (test/in3.txt)..... 9
 - 4. Dataset 4 (test/in4.txt)..... 9
 - 5. Dataset 5 (test/in5.txt)..... 10
- D. LINK GITHUB..... 11
- E. Tabel Penilaian Umum 11

A. Algoritma Penyelesaian Puzzle-15

➤ PART 1 : CHECKING

1. Kondisi awal papan puzzle (board) dicek kemungkinannya mencapai GOAL_STATE dengan menggunakan Bounding:

- Teorema : Status tujuan hanya dapat dicapai dari status awal jika $\sum_{i=1}^{16} KURANG(i) + X$ bernilai genap.
- $X=1$ jika sel kosong pada posisi awal ada pada sel yg diarsir

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

State awal

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

State akhir

Nilai dari $KURANG(i)$ untuk setiap $i \in \{1..16\}$ diambil dari penentuan posisi angka i ($POSISI(i)$) terhadap angka j ($POSISI(j)$), yaitu: (i dan j merupakan indeks posisi)

$$KURANG(i) = \sum_{POSISI(j) = POSISI(i)+1}^{16} (x_j)$$

dengan $x_j = \{0,1\}$. Note : $x_j = 1$ saat $(POSISI(j) > POSISI(i)) \wedge (j < i)$

- ✓ Jika nilai Bounding_Function genap, maka lanjutkan ke langkah 2,
- ✓ Jika nilai Bounding_Function ganjil, tampilkan pesan bahwa GOAL_STATE tidak mungkin tercapai.

➤ PART 2 : B&B Progress

2. Kondisi awal papan puzzle (board) yang merupakan simpul akar dimasukkan kedalam antrian prioritas pengecekan (PQ) dan merupakan simpul hidup dengan prioritas terendah (nilai 0).
3. Keluarkan elemen pertama antrian. Elemen ini menjadi simpul anak dari simpul sebelumnya jika bukan root.
- ✓ Jika simpul ini (*current_board*) merupakan GOAL_STATE maka tampilkan path yang telah dilalui oleh simpul ini (*current_board.prev_path*) dan simpul ini merupakan simpul daun,
 - ✓ Jika bukan, maka lanjutkan ke langkah 4.
4. Lakukan ekspansi *current_board* dengan semua kemungkinan simpul anaknya (*child_board*) berdasarkan piroritas urutan pergeseran balok kosong (*blank-block*) : Atas, Kanan, Bawah, dan Kiri. Jangan lupa untuk menambahkan arah pergeseran baru ke dalam path yang dilalui setiap simpul anak.
5. Untuk setiap simpul anak dari langkah 4, dihitung nilai *cost_total* nya dengan rumus:

$$cost_total = f_cost + g_cost$$

$$f_cost = child_depth \quad \& \quad g_cost = \sum_{POSISI(i)=1}^{16} FIT(i)$$

Dengan $FIT(i) = \{0,1\}$. Note : $FIT(i) = 1$ saat $i = POSISI(i)$

6. Setiap simpul anak dari langkah 5 dimasukkan ke dalam antiran prioritas pengecekan (PQ) dengan elemen berupa tuple (*cost_total, child_board*). Lalu dilakukan pengurutan berdasarkan nilai *cost_total* secara menurun.
7. Berdasarkan kondisi antrian prioritas PQ:
- ✓ PQ tidak kosong, ulangi langkah ke 3 hingga dicapai GOAL_STATE,
 - ✓ PQ kosong, tampilkan pesan bahwa GOAL_STATE tidak mungkin tercapai.
- > Sudah ditangani oleh Bounding_Function

B. Source Code

1. Board.py

Board.py > Board > G_cost

1 class Board():
2 ### Atribut Member
3 # f_cost : private
4 # blankX : private
5 # blankY : private
6 # prev_path : private
7
8 ### CTOR
9 def __init__(self, mat):
10 self.f_cost = 0
11 self.__mat = mat
12 self.__blankX, self.__blankY = self.searchBLANK()
13 self.__prev_path = ["none"]
14 ### CCTOR
15 # Di python memakai fungsi deepcopy()
16
17 ### SETTER & GETTER
18 # Matrix
19 def setMatrix(self, mat):
20 self.__mat = mat
21 def getMatrix(self):
22 return self.__mat
23
24 # f_cost
25 def setf_cost(self, f_cost):
26 self.__f_cost = f_cost
27 def getf_cost(self):
28 return self.__f_cost
29
30 # blank number
31 def setBlank(self, x, y):
32 self.__blankX = x
33 self.__blankY = y
34 def getBlank(self):
35 return self.__blankX, self.__blankY
36
37 # previous path
38 def getprev_path(self):
39 return self.__prev_path
40
41 ### COST MODIFIER
42 def incrementf_cost(self):
43 self.__f_cost += 1

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def G_cost(self):
 sum = 0
 for i in range(4):
 for j in range(4):
 pos = (i)*4 + (j+1)
 if self.__mat[i][j] != 16:
 if pos != self.__mat[i][j]:
 sum += 1
 return sum

def Total_cost(self):
 return self.__f_cost + self.G_cost()

PREV PATH MODIFIER
def continue_path(self, curr):
 self.__prev_path.append(curr)

Matrix MODIFIER
blank finder
def searchBLANK(self):
 x = -1
 y = -1
 for i in range(4):
 for j in range(4):
 if self.__mat[i][j] == 16:
 x = i
 y = j
 return x, y

OUTPUT
def printMatrix(self):
 print("/-----\\")
 for i in range(4):
 print("|", end="")
 for j in range(4):
 bil = self.__mat[i][j]
 if bil != 16:
 if bil < 10:
 print(f" {bil}", end="")
 else:
 print(bil, end="")
 else:
 print(" ", end="")
 if j!=3:
 print(" ",end="")
 else:
 print("|")
 print("\\-----/")

```

95 # MOVE
96 def move(self, dir):
97     x = self._blankX
98     y = self._blankY
99     # print(x,y)
100     xn = -1
101     yn = -1
102     if dir == "u":
103         xn = x-1
104         yn = y
105         # print(xn, yn)
106     elif dir == "r":
107         xn = x
108         yn = y+1
109     elif dir == "d":
110         xn = x+1
111         yn = y
112     elif dir == "l":
113         xn = x
114         yn = y-1
115     temp = self._mat[xn][yn]
116     self._mat[xn][yn] = 16
117     self._mat[x][y] = temp
118     self.setBlank(xn,yn)
119
120
121
122
123
124 def KURANGI(self):
125     KURANGI = [0 for i in range(16)]
126     for i in range(4):
127         for j in range(4):
128             # pos1 dan pos2 dalam rentang 1<= x <=16
129             pos1 = (i)*4 + (j+1)
130             temp = self._mat[i][j]
131             # Cek selanjutnya : J < I dan POSISI(J) > POSISI(I)
132             for k in range(4):
133                 for l in range(4):
134                     pos2 = (k)*4 + (l+1)
135                     if pos2 > pos1:
136                         if self._mat[k][l] < temp:
137                             KURANGI[temp-1] += 1
138     return KURANGI

```

```

140
141 def BOUNDING(self):
142     KURANGI = self.KURANGI()
143     sum = 0
144     for i in range(16):
145         sum += KURANGI[i]
146
147     # Jika blank ada pada daerah diarsir
148     if (self._blankX+self._blankY)%2 == 1:
149         sum += 1
150     return sum, sum%2==0 # int, bool = {jumlah KURANG(i)+X, apakah genap}
151
152
153 def printKURANGI(self):
154     KURANGI = self.KURANGI()
155     print("Tabel Nilai KURANGI: ")
156     print("|-----|")
157     print("| ANGKA| N |")
158     print("|-----|")
159     for i in range(16):
160         n = KURANGI[i]
161         if i+1 < 10:
162             if n < 10:
163                 print(f" |{i+1}| | {KURANGI[i]} |")
164             else:
165                 print(f" |{i+1}| | {KURANGI[i]} |")
166         else:
167             if n < 10:
168                 print(f" |{i+1}| | {KURANGI[i]} |")
169             else:
170                 print(f" |{i+1}| | {KURANGI[i]} |")
171     print("|-----|")
172
173 def printPATH(self):
174     for i in self._prev_path:
175         if i=="none":
176             continue
177         else:
178             print(f"{i} ->",end=" ")
179     print("GOAL")
180
181
182 ## COMPARATOR (YA Allah debug ini dari malem sampe 13 jam g tidur T_T)
183 def __lt__(self, other):
184     return True
185 def __le__(self, other):
186     return True
187 def __gt__(self, other):
188     return True
189 def __ge__(self, other):
190     return True

```

2. Other.py

```

1 from copy import deepcopy
2 import random
3
4 def readFile(filename):
5     filename = "test/" + filename + ".txt"
6     with open(filename, 'r') as f:
7         mat = [[int(num) for num in line.split(' ')] for line in f if line.strip() != ""]
8     return mat
9
10 def readManual():
11     print("Masukkan matrix 16 angka (dalam bentuk kotak dg spasi): ")
12     mat = [[0 for j in range(4)] for i in range(4)]
13     for i in range(4):
14         word = input()
15         mat[i] = [int(x) for x in word.split()]
16     return mat
17
18 def bigRandomize():
19     ran = random.sample(range(1,17),16)
20     mat = [[0 for j in range(4)] for i in range(4)]
21     for i in range(4):
22         for j in range(4):
23             mat[i][j] = int(ran[4*i + j])
24     return mat

```

```

26 def simpleRandomize():
27     ran = random.sample(range(12,17),5)
28     mat = [[0 for j in range(4)] for i in range(4)]
29     for i in range(4):
30         for j in range(4):
31             pos = (i*4 + j)
32             if pos < 11:
33                 mat[i][j] = pos+1
34             else:
35                 mat[i][j] = int(ran[pos-11])
36     return mat
37
38 def isGOAL_STATE(mat):
39     for i in range(4):
40         for j in range(4):
41             pos = (i*4 + (j+1))
42             if (pos != mat[i][j]):
43                 return False
44     return True
45
46 # Fungsi untuk menentukan simpul yang diexpand dan yang dimasukkan ke dalam antrian
47 def moveProgress(thisBoard, prev_Path, nextDirection, PQ, node_created):
48     thisBoard.incrementf_cost()
49     thisBoard.prev_path = deepcopy(prev_Path)
50     thisBoard.continue_path(nextDirection)
51     this_cost = thisBoard.Total_cost()
52     # PQ.append( (this_cost, thisBoard) ) # LIST IMPLEMENT
53     PQ.put( (this_cost, thisBoard) ) # Prio IMPLEMENT
54     node_created.count = node_created.count + 1

```

3. Main.py

```
1  from queue import PriorityQueue
2  from traceback import print_tb
3  from types import SimpleNamespace
4  from Board import *
5  from Others import *
6  import time
7  import msvcrt
8
9  def inputPilihan():
10     looping = True
11     time.sleep(0.8)
12     print("(1) for file input      (3) for random input")
13     print("(2) for manual input    (99) exit the program")
14     print()
15     op = int(input("Choose a number (1) or (2) or (3) or (99) : "))
16     print()
17     while not(op==1 or op==2 or op==3 or op==99):
18         print("YOUR INPUT NOT VALID..!! Please reinput a number within range..!!")
19         op = int(input("Choose a number (1) or (2) or (3) or (99) : "))
20         print()
21     if op == 1:
22         file = input("Now, please input your filename (without extension) : ")
23         Mtr = readFile(file)
24     elif op == 2:
25         Mtr = readManual()
26     elif op == 3:
27         Mtr = simpleRandomize()
28     elif op == 99:
29         print("Thanks a lot for using our porgram...!! />..<\\")
30         print("Have a nice day..!!")
31         print("~~~~~")
32         Mtr = []
33         # Gleen, 2 hours ago via PR #1 • FINISH#### ...
34     return Mtr
35
36 print("""
37
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C. CONTOH EKSEKUSI PROGRAM

1. Dataset 1 (test/in1.txt)

➤ Input

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

➤ Output:

```
Now, please input your filename (without extension) : in1
--> HERE IS YOUR INITIAL STATE of PUZZLE-15 <--
/-----\
| 1  2  16 4|
| 5  6  3  8|
| 9 10  7 11|
|13 14 15 12|
\-----/

-----
--> HERE IS THE CHECKING TABLE of BOUND <--
Tabel Nilai KURANGI:
|-----|
| ANGKA| N |
|-----|
|  1  | 0 |
|  2  | 0 |
|  3  | 0 |
|  4  | 1 |
|  5  | 1 |
|  6  | 1 |
|  7  | 0 |
|  8  | 1 |
|  9  | 1 |
| 10  | 1 |
| 11  | 0 |
| 12  | 0 |
| 13  | 1 |
| 14  | 1 |
| 15  | 1 |
| 16  |13 |
|-----|

Nilai dari sum_KURANG(i) + X adalah 22

-----
-->      !...SOLUTION FOUND...!      <--

--> INITIAL STATE of PUZZLE-15 <--
/-----\
| 1  2  4 16|
| 5  6  3  8|
| 9 10  7 11|
|13 14 15 12|
\-----/
-----
```

```
-----
--> Taken MOVE : BAWAH

/-----\
| 1  2  3 4|
| 5  6  8  |
| 9 10  7 11|
|13 14 15 12|
\-----/

-----
--> Taken MOVE : BAWAH

/-----\
| 1  2  3 4|
| 5  6  7 8|
| 9 10  11 |
|13 14 15 12|
\-----/

-----
--> Taken MOVE : KANAN

/-----\
| 1  2  3 4|
| 5  6  7 8|
| 9 10 11  |
|13 14 15 12|
\-----/

-----
--> Taken MOVE : BAWAH

/-----\
| 1  2  3 4|
| 5  6  7 8|
| 9 10 11 12|
|13 14 15  |
\-----/

Program Execution time : 0.0010035037994384766 seconds
                        : 1.0035037994384766 milliseconds
Count of Move Taken : 4
Path that able to take : d -> d -> r -> d -> GOAL
Count of Raised Node (living-node ever) : 12
-----
```

2. Dataset 2 (test/in2.txt)

➤ Input

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

➤ Output:

```
Now, please input your filename (without extension) : in2
~~~~~
--> HERE IS YOUR INITIAL STATE of PUZZLE-15 <--
/-----\
| 1  2  3  4|
| 5 10  6  7|
| 9   11  8|
|13 14 15 12|
\-----/

~~~~~
--> HERE IS THE CHECKING TABLE of BOUND <--
Tabel Nilai KURANGI:
|-----|
| ANGKA| N |
|-----|
|  1 | 0 |
|  2 | 0 |
|  3 | 0 |
|  4 | 0 |
|  5 | 0 |
|  6 | 0 |
|  7 | 0 |
|  8 | 0 |
|  9 | 1 |
| 10 | 4 |
| 11 | 1 |
| 12 | 0 |
| 13 | 1 |
| 14 | 1 |
| 15 | 1 |
| 16 | 6 |
|-----|

Nilai dari sum_KURANG(i) + X adalah 16

~~~~~
-->      !...SOLUTION FOUND...!      <--

--> INITIAL STATE of PUZZLE-15 <--
/-----\
| 1  2  3  4|
| 5 10  6  7|
| 9   11  8|
|13 14 15 12|
\-----/

~~~~~
--> Taken MOVE : ATAS

/-----\
| 1  2  3  4|
| 5   6  7|
| 9 10 11 8|
|13 14 15 12|
\-----/

~~~~~
--> Taken MOVE : KANAN

/-----\
| 1  2  3  4|
| 5  6   7|
| 9 10 11 8|
|13 14 15 12|
\-----/

~~~~~
--> Taken MOVE : KANAN

/-----\
| 1  2  3  4|
| 5  6  7  |
| 9 10 11 8|
|13 14 15 12|
\-----/

~~~~~
--> Taken MOVE : BAWAH

/-----\
| 1  2  3  4|
| 5  6  7  8|
| 9 10 11  |
|13 14 15 12|
\-----/

~~~~~
--> Taken MOVE : BAWAH

/-----\
| 1  2  3  4|
| 5  6  7  8|
| 9 10 11 12|
|13 14 15  |
\-----/

Program Execution time : 0.0019769668579101562 seconds
                        : 1.9769668579101562 milliseconds
Count of Move Taken : 5 Moves
Path that able to take : u -> r -> r -> d -> d -> GOAL
Count of Raised Node (living-node ever) : 15 Nodes
```


3. Dataset 3 (test/in3.txt)

➤ Input

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

➤ Output:

```
Now, please input your filename (without extension) : in3

--> HERE IS YOUR INITIAL STATE of PUZZLE-15 <--
/-----\
| 2 3 4|
| 1 6 7 8|
| 5 9 10 12|
|13 14 11 15|
\-----/

--> HERE IS THE CHECKING TABLE of BOUND <--
Tabel Nilai KURANGI:
|-----|
| ANGKA| N |
|-----|
| 1 | 0 |
| 2 | 1 |
| 3 | 1 |
| 4 | 1 |
| 5 | 0 |
| 6 | 1 |
| 7 | 1 |
| 8 | 1 |
| 9 | 0 |
|10 | 0 |
|11 | 0 |
|12 | 1 |
|13 | 1 |
|14 | 1 |
|15 | 0 |
|16 | 15|
|-----|

Nilai dari sum_KURANG(i) + X adalah 24
```

```
!--> !...SOLUTION FOUND...! <--

--> INITIAL STATE of PUZZLE-15 <--
/-----\
| 2 3 4|
| 1 6 7 8|
| 5 9 10 12|
|13 14 11 15|
\-----/

--> Taken MOVE : BAWAH

/-----\
| 1 2 3 4|
| 6 7 8|
| 5 9 10 12|
|13 14 11 15|
\-----/

--> Taken MOVE : BAWAH

/-----\
| 1 2 3 4|
| 5 6 7 8|
| 9 10 12|
|13 14 11 15|
\-----/

--> Taken MOVE : KANAN

/-----\
| 1 2 3 4|
| 5 6 7 8|
| 9 10 11 12|
|13 14 15|
\-----/

--> Taken MOVE : KANAN

/-----\
| 1 2 3 4|
| 5 6 7 8|
| 9 10 11 12|
|13 14 15|
\-----/

Program Execution time : 0.002021312713623047 seconds
                        : 2.021312713623047 milliseconds
Count of Move Taken : 6 Moves
Path that able to take : d -> d -> r -> r -> d -> r -> GOAL
Count of Raised Node (living-node ever) : 15 Nodes
```

4. Dataset 4 (test/in4.txt)

➤ Input

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

➤ Output:

```
Now, please input your filename (without extension) : in4

--> HERE IS YOUR INITIAL STATE of PUZZLE-15 <--
/-----\
|14 7 9 |
|11 6 15 8|
| 3 1 4 13|
| 2 5 10 12|
\-----/

--> HERE IS THE CHECKING TABLE of BOUND <--
Tabel Nilai KURANGI:
|-----|
| ANGKA| N |
|-----|
| 1 | 0 |
| 2 | 0 |
| 3 | 2 |
| 4 | 1 |
| 5 | 0 |
| 6 | 5 |
| 7 | 6 |
| 8 | 5 |
| 9 | 7 |
|10 | 0 |
|11 | 8 |
|12 | 0 |
|13 | 4 |
|14 | 13|
|15 | 9 |
|16 | 12|
|-----|

Nilai dari sum_KURANG(i) + X adalah 73

-->>> !...WARNING...! <<--
This Puzzle-15 can not be solved..! Because, its BOUNDING VALUE is ODD..
```

5. Dataset 5 (test/in5.txt)

➤ Input

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

➤ Output:

```
Now, please input your filename (without extension) : in5
~~~~~
--> HERE IS YOUR INITIAL STATE of PUZZLE-15 <--
/-----\
|   9  15  4 |
|11 13  8  6|
| 2  1  5 14|
|10  7  3  1|
\-----/

~~~~~
--> HERE IS THE CHECKING TABLE of BOUND <--
Tabel Nilai KURANGI:
|-----|
| ANGKA|  N |
|-----|
|  1  |  0 |
|  2  |  2 |
|  3  |  1 |
|  4  |  4 |
|  5  |  2 |
|  6  |  5 |
|  7  |  2 |
|  8  |  7 |
|  9  |  9 |
| 10  |  3 |
| 11  |  9 |
| 12  |  0 |
| 13  |  9 |
| 14  |  4 |
| 15  | 13 |
| 16  | 15 |
|-----|

Nilai dari sum_KURANG(i) + X adalah 85

~~~~~
--->>   !...WARNING...!   <<---
This Puzzle-15 can not be solved..! Because, its BOUNDING VALUE is ODD...
~~~~~
```

D. LINK GITHUB

Source code dan laporan dapat diakses melalui:

https://github.com/Amike31/Tucil_Stima_3

E. Tabel Penilaian Umum

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